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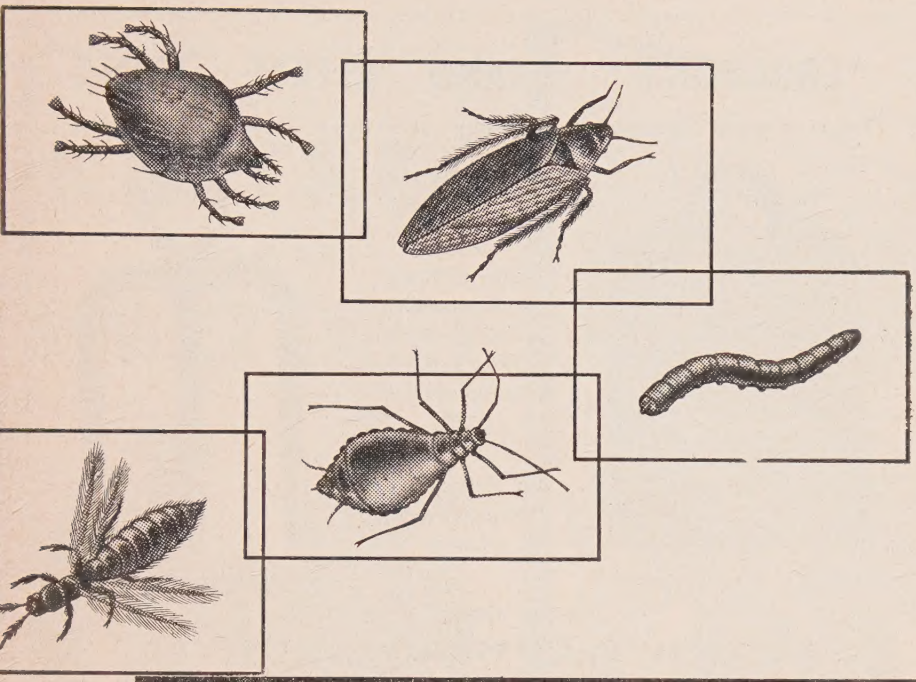

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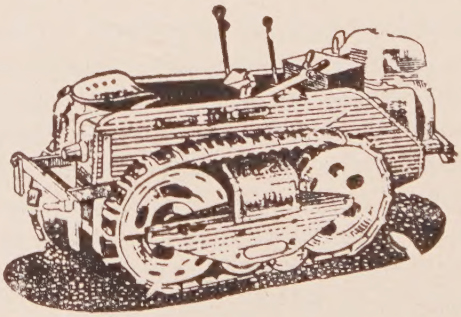

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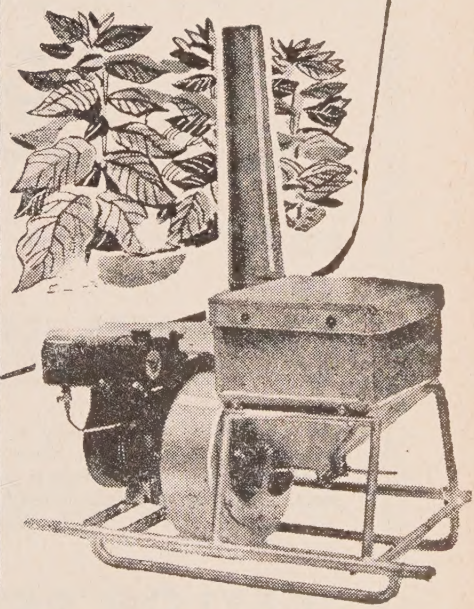

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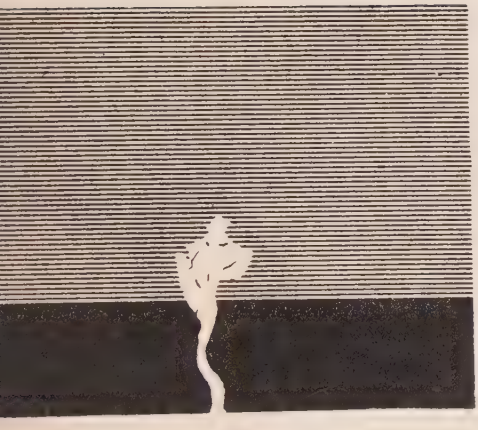

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Director of Agriculture

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EDITORIAL

Chemical Weed Control in the Tropics

THE increasing use of chemical weed killers, particularly of the growth-hormone type has been a feature of agriculture in the post-war period. The crop acreage that today benefits from chemical weed control has been estimated at one hundred million acres. Only a small fraction of this acreage is in the tropical latitudes. Paucity of information appears to be the main reason for the relative lack of popularity of chemical methods of weed control in the tropics. Indeed, on purely theoretical grounds, it may be argued that chemical weed control is of particular importance under tropical conditions. Results obtained at the Dry Zone Research Station at Maha Illuppalamma have, for instance, demonstrated that as tillage with the soil-pulverizing implements traditional to temperate latitudes can effect almost irreparable damage to tropical soils, dependence on weedicides must increase.

In the period antecedent to World War II, weedicides in general use were largely inorganic, and included arsenic compounds, chlorates, sulphuric acid, mineral oils, weedicidal fertilizers, cyanamides, copper salts and D.N.O.C. With the discovery by Templeman at Jealott's Hill, in 1940, of the selective weedicidal action of growth regulators, the picture changed. Secrecy regulations current in the Second World War prevented the publication of Templeman's findings at the time but intensive research on the weedicidal action of growth-hormones proceeded. In 1942 almost simultaneously in Britain and the U. S. A., the selective weedicidal action of chlorinated phenoxyacetic acids was demonstrated : 2, 4—D and MCP which proved particularly effective in the early experiments of both the British and the American workers still retain their pre-eminence among commercial weedicides.

Growth-hormones have a variety of uses, e.g., as rooting stimulants for cuttings, as sprouting depressants for tubers, for inducing parthenocarpy, fruit ripening and defoliation and for inhibiting pre-harvest fruit drop. It is however as selective post-emergence weedicides that growth-hormones find their most extensive use.

Comprehensive studies of chemical weed control that have been in progress at the Dry Zone Research Station, Maha Illuppalama, indicate that although weedicides fill an important place in arable

farming, they must, at least in the present be considered as reinforcing, rather than replacing, the effects of mechanical weeding. Pre-emergence applications of selective weedicides like PCP or DNBP do not alone ensure the continued weed-free growth of crops ; pre-emergence weed killers must be supplemented by mechanical weeding if resistant species—particularly grasses—are to be eliminated. An effective routine of weed control in the Dry Zone is the pre-emergence application of either PCP or DNBP (at 2 gallons 12 per cent formulation and 1 gallon 17 per cent formulation per acre respectively) just after sowing, followed by 2 to 3 mechanical weedings at 10 to 15 day intervals commencing 10 to 15 days after sowing. This routine possesses sufficient elasticity to cover a wide range of conditions, and gives high yields of maize, sorghum, cotton and upland rice. The superiority of DNBP to PCP has not been significant, and as PCP is cheaper and less hazardous, it becomes the obvious choice.

Trials with urea and carbamate weed-killers on the cotton crop have shown marked promise in this country : pre-emergence application of DCU at 4—8 lb. per acre has given three weeks of weed-free growth. At higher dosages, DUC tends to be toxic to cotton. CIPC and IPC though somewhat inferior in their weedicidal action are strikingly less phytotoxic.

Except perhaps in the ill-drained areas south of the Kelani Ganga, where broad-leaved species form an important component of the weed flora, it is unlikely that selective weedicides will find a place in the culture of swamp rice in Ceylon for several years to come. Not only do grasses compose a large fraction of the weed population in paddy lands in most parts of Ceylon, but the continuous use of selective weedicides would contribute to the increasing dominance of grass species.

SOME EFFECTS OF IPC AND CIPC ON GROUNDNUTS

By S. T. W. Kirinde

(Agronomist, Dry Zone Research Station, Maha Illuppallama, Ceylon)

SUMMARY

Groundnuts grown in pots were treated with IPC and CIPC at each of the following stages:—(*a*) pre-emergence, (*b*) emergence, (*c*) 4-leaf stage or 7-8 days from emergence, (*d*) 5-leaf stage or 14-15 days from emergence and (*e*) flowering or 24-25 days from emergence.

The chemicals were applied in the form of a dust at the rate of 1.0 lb/ac. active material; common responses evoked were death of seedlings, stunting, chlorosis and curling of leaflets. Resistance to the effect of the chemicals increased with the age at application, but whereas CIPC depressed the final yield in terms of nut number and weight by application at all five stages, IPC depressed yield compared with untreated controls only by application at or earlier than the 4-leaf stage.

INTRODUCTION

The control of weed grasses is one of the most difficult problems encountered in highland cropping in the dry zone of Ceylon; their control in crops such as cotton, groundnuts, maize, sorghum and highland paddy has so far been mechanical, either by means of tractor-drawn rotary weeders and intercultivators, or more usually, by gangs of labourers wielding hoes.

Chemical weed control in highland crops has up to now been confined to the pre-emergence application of 2, 4-D, PCP and DNBP; post-emergence treatments have not been of much success due to the predominance of grasses among the weed flora. Earlier experiments have shown that a pre-emergence treatment of either Pentachlorophenol (PCP) or 2, 4-dinitro-6-sec-butyl phenol (DNBP) to get rid of the dicotyledonous species, followed by two or three post-emergence hand weedings to control the grasses, is a useful routine, but it was not greatly superior to three or four hand weedings alone.

Among the chemicals used for the control of grasses in standing crops, varying degrees of success have been achieved with the phenyl carbamates, especially CIPC, particularly in cotton, soyabean, lucerne and sugar beets. The experiment described below was undertaken as a preliminary study in the chemical control of weeds in a legume crop rapidly gaining in importance in the dry zone of Ceylon.

MATERIAL AND METHODS

The groundnut variety "Uganda Erect" was grown in 12″ clay pots at the rate 16 seeds per pot ; all pots were thinned at the four-leaf stage to eight plants and at flowering to four plants per pot.

Pure isopropyl-N-Phenyl carbamate (IPC), and isopropyl-N-(3-chlorophenyl) carbamate (CIPC), were applied to the groundnuts at each of the following stages :—(*a*) pre-emergence, (*b*) emergence, (*c*) the 4-leaf stage or 7-8 days from emergence, (*d*) the 5-leaf stage or 14-15 days from emergence and (*e*) flowering or 24-25 days from emergence.

The chemicals were applied at approximately 1 lb/ac. active material. For application, each chemical was made into a 4 per cent. mixture with oven-dried clay ; 1.0 gm. of this heavy mixture was then mixed with a further 5.0 gram. clay and dusted over the entire surface of the soil at each time of application.

There were two blocks of 12 pots each, made up of 2 × 5 chemical treatments plus 2 untreated controls per block ; due to the small number of replicates the experiment was repeated twice, but results of only the second experiment are given.

RESULTS

1. Effect of pre-emergence application

The chemicals were dusted on to the bare soil soon after planting. Germination in all pots commenced on the fifth day after planting ; in the controls germination continued for about two days and attained a maximum of about 70 per cent. In pots treated with IPC, germination in a large number of seeds did not progress beyond the radical stage ; these cases of arrested germination were soon subject to heavy secondary fungal infection and died with the cotyledons still within the soil. With CIPC the maximum percentage germination approximated that of the controls, and nearly all these seedlings had their cotyledons and plumules raised above the soil.

Completely emerged seedlings in both IPC and CIPC treated pots were extremely chlorotic and five to seven days after emergence were less than 15 mm. in height ; they had only two leaves, borne on short, thickened petioles 15-20 mm. long ; the leaflets in these were correspondingly tiny, thin, pale greenish yellow in colour and not fully expanded. Untreated controls of the same age were 25-30 mm. tall, and had two fully expanded leaves with a partially expanded third leaf, and an emerging fourth. Petioles in the controls were 50-55 mm. long and bore leaflets with a long axis of about 1 inch.

Judging from the number of seedlings soon after emergence, CIPC would appear to be less toxic than IPC, but whereas the few seedlings that arose under IPC recovered from the effects of the chemical and resumed normal growth, all the CIPC treated seedlings died within three weeks of emergence ; in this case too, secondary fungal infection of affected seedlings was very heavy.

Results of pre-emergence application are summarised in Table I.

TABLE I.—Effect of ICP and CIPC applied pre-emergence to Groundnuts

Treatment	Seed No. planted	Number germinated	Number plumules	Number Survivals	Days Emergence to flowering	Number Harvested	Number of Nuts		Weight of Full nuts
							Full	Empty	
IPC	32	13	5	3	40	3	13	14	17·50
CIPC	32	22	18	—	—	—	—	—	—
CONTROL	32	23	23	23	23	8	24	12	44·00

2. Effect of Application at Emergence:

The groundnut seedling at emergence has a pair of cotyledons with a bud in each axil, and a plumule consisting of two folded leaves with a crown of stipules between them. The general colour of the seedlings is maroonish, although the leaflets themselves are pale yellowish green. Within twenty-four hours of emergence the first two leaves begin to unfold and the third leaf commences to appear through the crown of stipules. In another twenty-four hours the first two leaves are fully expanded and dark green in colour, and the emergence of the third leaf is completed although its leaflets still remain folded ; the emergence of the fourth leaf from between the stipules of the second and third leaves also commences at about the same time. Five days after emergence, the plant has four fully expanded leaves and an emerging fifth. After this period of rapid growth, an apparent lull seems to set in, for the expansion of the fifth leaf is completed only when the plant is about two weeks old. By this time, too, the buds

in the axils of the cotyledons have developed into branches with 2-3 leaves, while the opening of the buds in the axils of the first and second leaves has just begun.

Application of CIPC at emergence brings further growth to a virtual halt. The chemical is rapidly translocated to the plumule, where it stunts the growth of the first and second leaves whose leaflets get a diffused chlorosis and are curled downwards and inwards. The developing third and fourth leaves are even more severely affected ; although they emerge from among the stipules, they do not grow to more than 20 mm. in length, and their leaflets become completely chlorotic and rolled inwards ; there is no elongation of the internodes and the plants remain less than 15 mm. in height (Fig. 1). These seedlings die off sooner or later without recovering from the effects of the chemical.

IPC applied at emergence (Fig. 2), does not have such a drastic effect on the growth of the seedlings. The first, second and third leaves get an initial chlorosis, but they soon recover and continue to grow normally ; the fifth, sixth and seventh leaves however are rather more severaly affected, the most striking feature being the abortion of their leaflets ; this condition diminishes progressively with maturity, so that the seventh leaf shows the least amount of abortion, while the morphological features of the eighth leaf are more or less normal. The growth of the plant thereafter proceeds normally, but flowering is delayed and yield is reduced.

The general results of IPC and CIPC applied at emergence are summarised in Table II.

TABLE II.—Effect of IPC and CIPC applied to Groundnuts at Emergence

Treatment	Seedling No. at treatment	No. after first treatment	No. after second thinning	Mortality	Days : Emergence to flowering	Number harvested	Number of nuts		Wt. of full nuts
							Full	Empty	
IPC	25	16	8	Nil	Over 40	8	19	18	34·0
CIPC	24	16	8	7	Over 40	1	2	7	3·8
CONTROL	22	16	8	Nil	23	8	24	12	44·0

3. Effect of application at the 4-leaf stage, 5-leaf stage and at flowering :

The first seven days after emergence is a period of rapid leaf production, for at the end of that period, the main stem bears four fully developed leaves, while the fifth leaf is fully opened only by

the end of the second week. But during the second week, buds become prominent in the axils of the first, second and third leaves ; growth of these buds takes place in the course of the third week, and at twenty-one days, the main stem bears six fully opened leaves, with single-leaved branches in the axils of the first and second leaves. Growth thereafter is somewhat mixed, for the first flower buds may be detected at about twenty-three days from emergence, while growth of the seventh and eighth leaves on the main stem and also development of branches in the axils of the third and fourth leaves take place during that time.

IPC or CIPC applied at either of the growth stages described above, gets rapidly translocated to the youngest leaves on the main stem ; thus applied at the 4-leaf stage, the first two leaves are unaffected, while the third leaf may show a trace of chlorosis ; chlorosis is more widespread in the fourth leaf which has only just been fully opened, while the fifth leaf when it emerges is completely chlorotic. The effect of the chemicals is less marked in the sixth leaf while the seventh and eighth leaves develop normally. The most striking difference between IPC and CIPC applied at either of these stages is that while IPC induces only a chlorosis, CIPC also causes the leaves to roll.

Applied at the 5-leaf stage and at flowering, the effect of the chemicals follows a pattern similar to that when applied at the 4-leaf stage ; at the 5-leaf stage, however, the third leaf of the branches in the axils of the cotyledons is also affected ; no branches were affected by application at the 4-leaf stage and at flowering.

The chemicals did not affect the floral morphology but the emergence to flowering interval was prolonged by application at the 4-leaf and 5-leaf stages. The general results of application at these various stages are summarised in Table III, while Figure 3 shows the effect of CIPC applied at the 4-leaf stage.

TABLE III.—Effect of IPC and CIPC applied to Groundnuts at three different stages of Growth

Treatment	Stage of Growth	Number Treated	Mortality	Number Harvested	Days : Emergence to flowering	Number of nuts		Weight of full nuts
						Full	Empty	
IPC	4-leaf	16	Nil	8	30	24	26	36·3
	5-leaf	16	Nil	8	39	26	14	45·0
	flowering	16	Nil	8	23	31	21	43·5
CIPC	4-leaf	16	Nil	8	33	19	21	31·3
	5-leaf	16	Nil	8	Over 40	25	18	34·0
	flowering	16	Nil	8	23	22	11	36·0
CONTROL ..			Nil	8	23	24	12	44·0

DISCUSSION

From the results described above, it is possible to distinguish two distinct effects of IPC and CIPC on groundnuts. The first is their effect on mitosis, cell division and morphogenesis. The phenyl carbamates are generally considered to be potent mitotic poisons, and such symptoms as the curling and abortion of leaflets, stunting of the plant and the site of action being consistently the region round the stem apex are all evidence of this mode of action. Chlorosis in the youngest leaflets appears to be an entirely distinct effect of these chemicals, for in plants treated at the 4-leaf stage or later, there is complete recovery from it, while the symptoms of mitotic poisoning persist. Death of seedlings treated before or at emergence could thus be ascribed to the combined effects of both mitotic poisoning and chlorosis.

Another feature in the effect of IPC and CIPC on groundnuts is the general increase in resistance to the chemicals with age ; but at comparable stages of growth CIPC always exerts a more pronounced effect than IPC, and thus for example, while the yield of groundnuts with IPC applied at the 5-leaf stage or later is similar to that of the untreated controls, the yield of nuts with CIPC applied at the same stages is appreciably less.

The increase in resistance to the chemicals with age appears to be tied up with the amount of chlorophyll in the plant ; thus a seedling treated before, or at emergence, has little or no chlorophyll and is most severely affected ; but seedlings treated at the 4-leaf stage or later are progressively less affected and recover correspondingly faster. It appears as if the greater amount of chlorophyll in the older plants enables them to breakdown the chemicals rapidly into harmless products ; the apparent selective translocation of the chemicals to the apical region of the stem seems to point out an ability of the chlorophyll in the older leaves to repel entry of the chemicals into them, or to an extremely swift breakdown of the material almost as soon as it enters the mesophyll.

In conclusion, the distinction between IPC and CIPC does not lie in a fundamental difference in their mode of action, but rather in the relative degree of toxicity to groundnuts at comparable stages of growth ; where IPC temporarily retards growth, CIPC completely kills off seedlings ; where IPC causes abortion of leaflets, CIPC prevents their development altogether ; and where IPC induces a slight curling, leaflets are tightly rolled in the case of CIPC ; in other words, any effect of IPC is only being expressed in greater degree by CIPC. If the rate of breakdown of both IPC and CIPC within the groundnut

is the same, then the more pronounced effects of CIPC could be a result of the greater volatility of IPC as compared with CIPC, for then, over a given period of time, under the hot dry conditions in the dry zone, groundnut is likely to absorb more CIPC than IPC, with the former thus appearing to be more toxic than the latter.

ACKNOWLEDGMENTS

We are deeply grateful to Messrs. Joseph Weil & Son of London, who supplied us with samples of pure 'Mirvale' IPC and CIPC for our experiments.

OBSERVATIONS ON THE SYSTEM OF INSECT PEST FORECASTING IN JAPAN

By P. MANICKAVASAGAR
(Plant Protection Officer, Ceylon Department of Agriculture)

PLANTS have been introduced by man from one country to another, and along with them new pests, to places which had been free of them. Under natural conditions, insects have numerous enemies which keep them under check. But with man's interference, the balance has been upset. At the present moment, insect pests of cultivated crops are so numerous that they are a constant challenge to the ingenuity of man. As a result, man has evolved various methods to combat them on a very high scientific level. Although most farmers are aware of the existence of insect pests, they seldom suspect their presence until the crop is severely damaged. Control measures adopted with the aid of new and potent insecticides have at times proved uneconomical, as they have not been properly timed. In order to effect control measures at the proper time, and for them to be economical, a forecast of insect pest outbreak is essential.

The technique of insect forecasting in relation to the rice crop is one of the most important items of research work done for well over twenty years in Japan. Japan is proud of her achievement, as it is the only country that has envolved such a system in the rice growing regions of the world. The total area of land under cultivation in Japan is 14,936,410 acres. The acreage is composed of 8,241,370 acres of rice and 6,695,050 of highland crops. Rice is the staple food of the Japanese, as it is in all other South-East Asian countries. Hence it is not surprising to find that insect pest forecasting has been focussed on rice.

In 1886 a severe outbreak of *Chilo suppressalis* occurred in the northern limit of Honshu, and in the following two years severe outbreaks of *Schoenobius incertulas* Wlk. occurred in the northern part of Kyushu. These outbreaks of borer pests seem to have initiated the investigation of their bionomics, and the adoption of extensive control measures by means of " light traps ". According to Takahashi (1923) the recommendation of using light traps could be found in the directive issued by the Bureau of Agriculture in 1883, to the prefectural governments, in which it was stated that a fire made

around paddy fields in the evening fortnightly would not only decrease the population of insects, but also be helpful in accumulating data on the yearly occurrence of insect pests. By 1890, Agricultural Experimental Stations had been established in most prefectures, and light traps were set up in such stations to obtain quantitative records of insect occurrence with vague ideas of utilizing these records for insect pest forecasting

As the cultural standards were intensified by the adoption of improved varieties and heavy application of artificial fertilizers, the outbreak of injurious insects showed a tendency to increase gradually. With the entry of Japan into war with China, the necessity for increase in rice production was realised, and a programme for increased production was set in force in 1940. The same year faced a very severe outbreak of leaf hopper in Southern Japan, resulting in the loss of 300,000 tons of rice. This unforeseen set-back to the rice production programme made the government realise the importance of the control of insect pests in achieving the production target. In the following year, forecasting the outbreak of insect pests and diseases was taken up as an important phase of agricultural improvement on a nation-wide scale, in the establishment of a pest and disease forecasting service in the prefectures, by the Ministry of Agriculture.

ORGANIZATION

Japan, which is constituted of four main islands Hokkaido, Honshu, Kyushu and Shikoku, along with other satellite islets, has an area of about 90.4 million acres and stretches in a north-east to south westerly direction between 30° and 60° latitude. The country is mostly mountainous and cultivable land is of the alluvial type, formed by the deposits of the numerous rivers. Due to its geographical situation, the climate is very much influenced by monsoons, and rainfall is abundant, ranging from 40-120 inches per annum. Monsoons from the Pacific bring in much rain during the summer, and the winds from the continent cause plentiful snowfall in winter on the belt of land facing the Japan Sea. Geographical and climatic conditions divide the country into various zones and much attention has been paid to the location of detection units and observatories for insect pest forecasting as indicated in Fig 1.

Japan is divided into 46 prefectures or "ken". Each prefecture is subdivided into cities or " shi " and counties or " gun ". Counties are in turn marked on into towns or " cho " and villages or " mura ". The smallest division of the county is " buraku " consisting of 40-50 households. The prefectures are the centres of activity for the insect pest

and disease forecasting service. The service is manned by full-time technical officers stationed in each prefectural experiment station. Generally the prefectural forecasting stations are in charge of an entomologist or pathologist. Each station may have three entomologists or pathologists. There are at present 132 such officers, and of

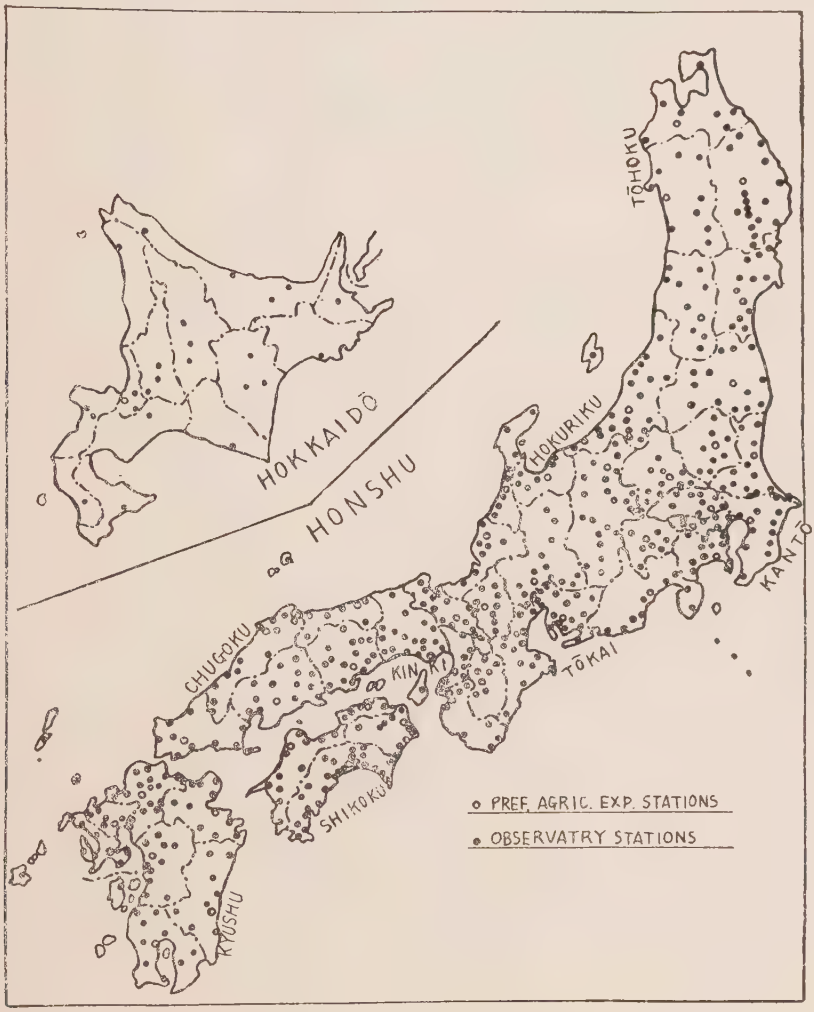

Fig. 1.—Network of Observatory Stations in Japan for predicting outbreaks of insect pests and diseases.

this number 45 percent are entomologists and the rest pathologists. Each prefectural station has 8-25 observatories in charge of junior entomologists and pathologists, for compiling and recording the insect

pest and disease fluctuation, atmospheric changes, changes in agricultural practices and other environmental factors. The number of such stations has been increased from 276 to 540 in recent years, and are distributed at the rate of one per city and "gun". Each of these observatories has, on an average, four detection units for the forecasting of rice stem borer and rice blast. Two thousand, one hundred and sixty detection units cover the entire country for the forecast of insect pests alone. The detection units are handled by experienced and reliable farmers, prefectural extension staff and by officers of co-operative societies who possess a knowledge of plant protection activities. The staff of the observatories instruct and direct them in taking the necessary observations.

WORKING OF EACH UNIT

The detection unit is equipped with an insect light trap, as in Fig. 1, and a small stretch of paddy field, usually less than a quarter of an acre in extent, to make the necessary observations on the development phase of insect pests and dissemination of spores. The location of the light trap and observation plot is permanently fixed. A dry type light trap provided with a 60 W incandescent lamp is preferred to that of the wet type, as the insects trapped in the latter tend to swell and get distorted.

The light traps are set from dusk to dawn during the cultivation season, i.e., May to October, and the trapped insects are separated into important species, and sexes. Such entries are made in the respective columns against the previous day. The entries of each set of five days are sent to the observatory at the end of the fifth day.

The observatory stations are also equipped with light traps, spore traps and an observation plot. In addition to these, hand nets, meteorological equipment, thermostat, torsion balance, and one motor vehicle are provided. Daily observations on the catches in traps and meteorological changes are recorded. The occurrence of insects and their rate of infestation are recorded at given intervals. The observatories also collect the records from the detection units under them, and pass them on to the prefectural experiment stations.

The prefectural stations carry out the same functions as the former two. The staff in such stations statistically analyse the records of the detection units and observatories to assess the period of pest outbreaks at prefectural level. In addition, they conduct fundamental investigations to improve the forecasting system. Each prefecture sends the results of the analysis to the Plant Protection

Fig. 1.—A Dry Type Light Trap.

Section of the Ministry of Agriculture and Forestry twice a month. The Ministry, on the basis of such reports, issues an insect pest forecast for the prefectures as well as the whole country. This information is passed on to the farmer through newspapers, radio

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broadcasting services, co-operative societies and the agricultural extension staff.

ANNUAL EXPENDITURE

The central government subsidises the prefectural governments with half the estimated total budget each year. Table 1 is an extract of the subsidy by the Central Government for the pest and disease forecasting and control services throughout Japan for the fiscal year 1959-60.

Table 1—Subsidy Budget of the Central Government to Local Bodies for Pest and Disease Forecasting and Control, 1959-60

Forecasting :—		
Personal emoluments :		
130 persons at prefectural stations		
540 persons at observatories	Y	67,651,000
Expenditure for recording of observations at 48 Exp. St. and 540 Observatories	Y	49,670,000
Expenditure for maintenance of traps and observation plots		
2160 for insect pests		
2160 for spores	Y	12,979,000
Expenditure for special investigations to improve the system of forecasting	Y	2,849,000
Total ..	Y	133,149,000
Pests and Disease Control .—		
Travelling for 518 officers	Y	5,284,000
Consumable articles	Y	1,915,000
Transport and Postage	Y	1,404,000
Labour Cost	Y	9,780,000
Total ..	Y	18,383,000

FUNDAMENTAL BASIS OF INSECT FORECASTING

In order to set up an insect pest forecasting project, fundamental studies have to be done on the insect pests, their hosts, and atmospheric conditions. This involves intensive observations in the laboratory as well as the field. In the laboratory, the species have to be determined. A thorough knowledge on the development and growth, physiology, and ecological aspects of the pest have also to be acquired. Determination of body weight of insects in every generation will indicate their vitality. Vitality of insects and the sex ratio would be good clues in the study of population density. The physiological state of the host plant too has a considerable effect on the insect pest population. The hosts may not possess, at

any particular stage of their growth, the full complement of nutrients for the healthy development of the insect pests. This fact should be taken into account in the forecast of pest outbreaks in regions where agricultural practices are not uniform. Physiological conditions of hosts vary from variety to variety, and also to a great extent on the type of soil on which it is grown.

On the field, very detailed observations have to be maintained in respect of atmospheric changes, systems of crop cultivation, cultural practices and other aspects that would bring about a fluctuation in the insect population. The same insect pest would behave differently according to climatic and geographical regions. For instance, *Chilo suppressalis* (Walk) is distributed all over Japan, but it has specific dates of peak emergence in cold, cool, warm and warmer regions, as indicated in Fig. 2. Hokkaido lies in the cold region and the *Chilo* has one generation, with its peak emergence in August. Fukui comes under the cool region and the pest undergoes two generations with the peaks of emergence in early June and late July. In the warm regions of Okayama the moth has a big first generation with mid June peak emergence and a small second generation with mid August peak emergence. Kochi falls in the warmer regions, having three generations. Such regional variations in the number of moths, generations, and peak of emergence are also influenced by the system of agriculture practised. Hokkaido has one cropping system ; Fukui and Okayama have two crops per year, i.e., rice and winter crops ; whereas Kochi has two rice crops and one winter crop.

The atmospheric changes have a great effect on insect pest abundance and emergence. Low temperature during any particular cropping season retards the activity of certain insects, and their breeding. A specific instance in Japan is the fluctuation of leaf hoppers of rice as is shown in Fig. 3. According to the graph, the outbreak of the pest is very marked in years having 40 to 50 per cent. sunshine hours in the month of June.

A uniform change brought about by farmers in any particular region can cause an upset in the behaviour of insects. In recent times, the system of early cultivation and double cropping of rice has been adopted in the south-western part of Japan. This change-over has an effect on the rice borer as shown in Fig. 4. The graph shows the light trap records for the months of May-September from 1952 to 1957. The system of rice cultivation changed in the year 1954, and it had an effect on the peak emergence of *Chilo suppressalis* and its early appearance. But in 1957 the emergence was delayed due to abnormal low temperature in the early Part of the year.

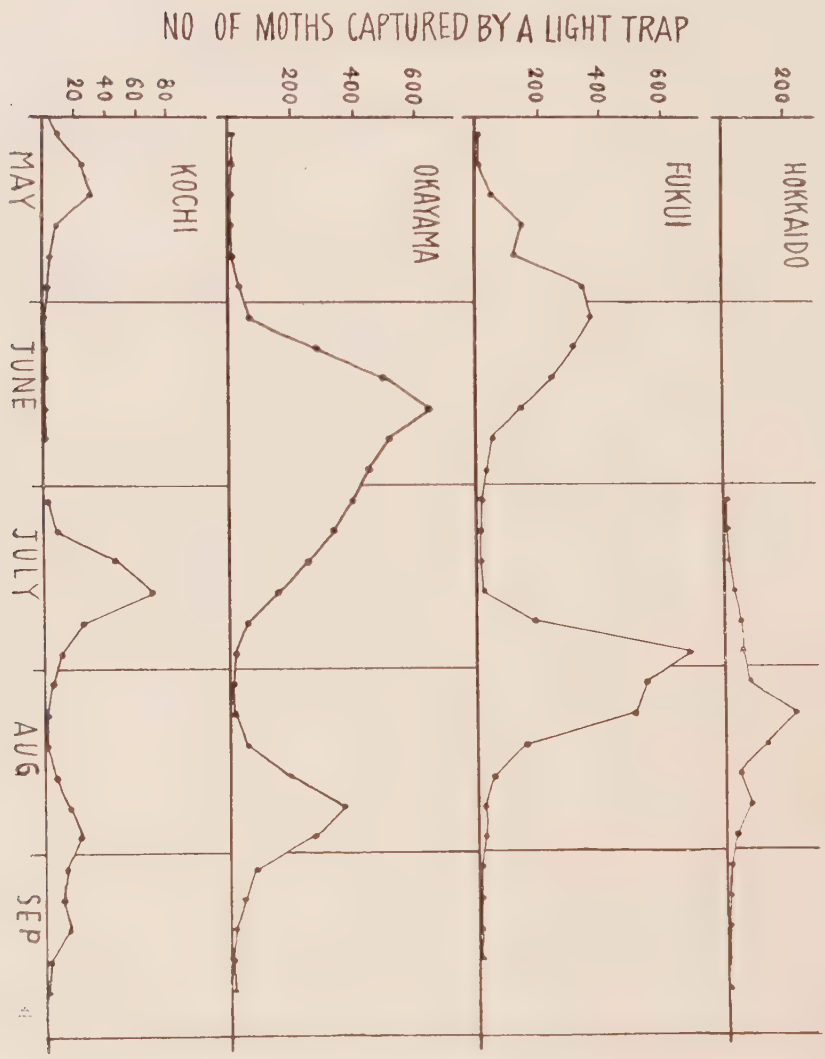

Fig. 2.—The type of moth emergence in the Four Regions of Japan.

The amount of artificial fertilizers applied to crops has an influence on the fluctuation of certain insect pests. This is clearly indicated in Fig. 5. Each unit of hectarage in the graph is 1,000 for *Chilo suppressalis,* and 100 for *Schoenobius incertulas.* The intensity of *Chilo suppressalis* infestation was low in the war years, and gradually increased thereafter with copious application of ammonium sulphate. But the infestation commenced dropping as from 1953, in spite of the steady

increase in manurial application. This change is due to the fact that parathion came into use in 1953. Till 1953 there was no practical method of control for *Chilo suppressalis.*

Schoenobius incertulas was kept under check by various cultural methods of control up to 1944, and such practices were relaxed due to shortage of labour just after the war. With the advent of DDT in 1959 *Schoenobius incertulas* was controlled by adopting insecticidal applications.

Apart from the above mentioned field observations, the first appearance, peak emergence, population density, date of last appearance, migratory habits, aestivation or diapause, and alternate hosts of insect pests have to be looked into. A knowledge of the insect pest population density alone will not be sufficient for the forecast.

SYSTEMS OF FORECASTING

Two systems of forecasting are in vogue in Japan. One is the statistical, and the other, the experimental. In the statistical method, light trap and other records of the insect population fluctuations are analysed in relation to environmental conditions. A daily count of the trapped insects is taken according to species and sexes. A moving average of five days is made to indicate more correctly the beginning, peak and end of emergence. The dates of commencement, and end of insect appearance are not so significant from the point of view of forecasting, as they are controlled by chance. The beginning and end of insect emergence are better judged by the dates on which 5 per cent and 95 per cent of insects are caught by light traps. The date of peak emergence is a good guide for the proper timing of insecticidal application. For practical purposes, the light trap should be maintained in a continuous sequence for several years, before commencing to forecast.

In the absence of any accumulated information on the population fluctuations of insect pests, it is possible to forecast the date of emergence and outbreak by the experimental method. This method involves the regular inspection of the development phase of the pest in question, in the field as well as in the laboratory. Such records when analysed, will reveal an accurate date of peak emergence of the insect. For example, the date of peak emergence of the lepidopterous insects can be read from the pupation chart in which the percentage of pupation is expressed in probit, in relation to the date of inspection. The date of peak emergence of the moth could be assessed from the pupation probit diagram, by adding the period of pupal duration to the date

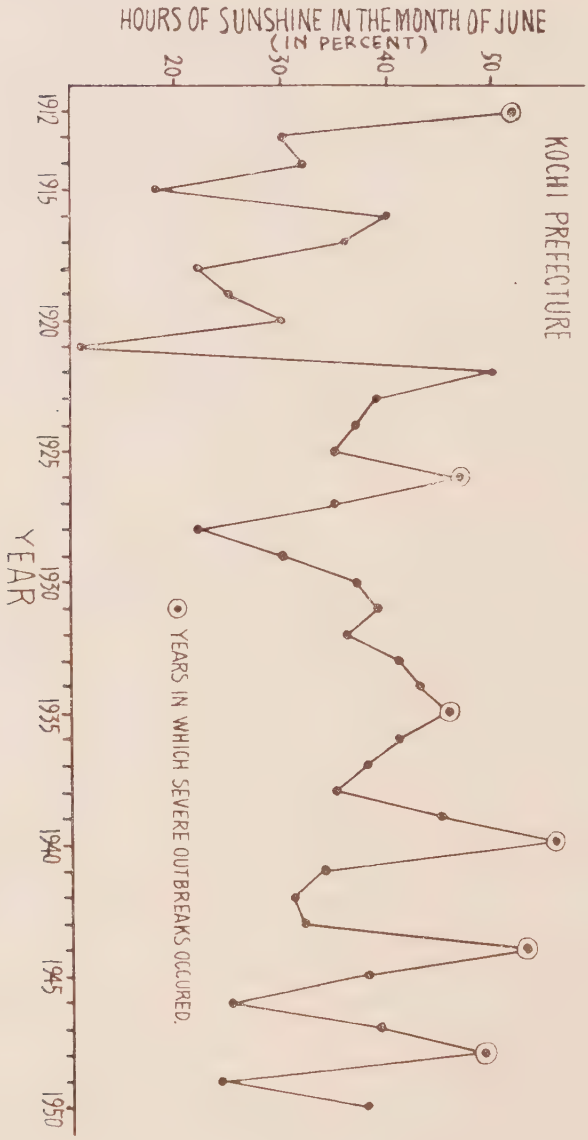

Fig. 3.—Influence of sunshine (June) on the outbreak of leaf hoppers.

of peak pupation which is expressed by the value of probit at 5. Even if there should be accumulated information on any pest population, it would be advisable to conduct the statistical and experimental methods side by side.

DISCUSSIONS AND CONCLUSIONS

The intention of this paper was to give a brief idea of the insect forecasting service in Japan. The information on the subject was gathered in the course of inspection tours and discussions with the Entomologists of the National Institute of Agricultural Sciences, Nishigahara, Tokyo, and of the Experimental Stations.

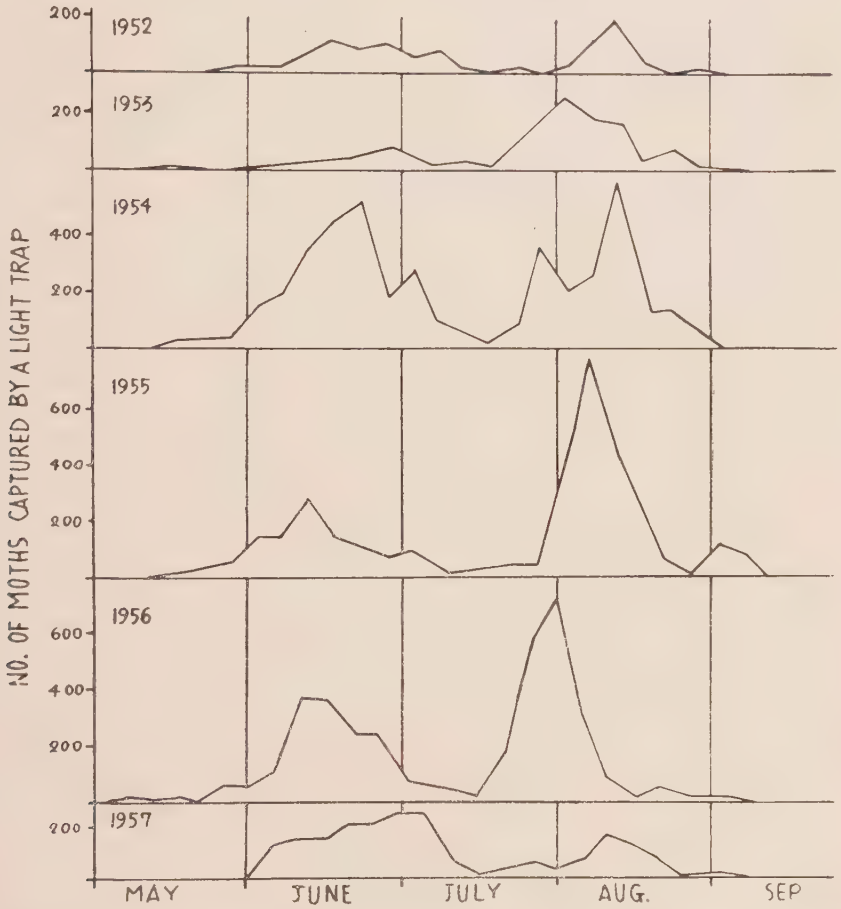

Fig. 4.—Light trap records of Kagashima Prefectural Experiment Station indicating the effect of change in the date of planting on the rice borer appearance.

The accurate forecasting of insect pest outbreaks has helped the Japanese farmers to take timely and uniform action in the application of insecticides on an economic basis. It has also helped in altering the date of planting of the rice crop in order to avoid serious pest infestations.

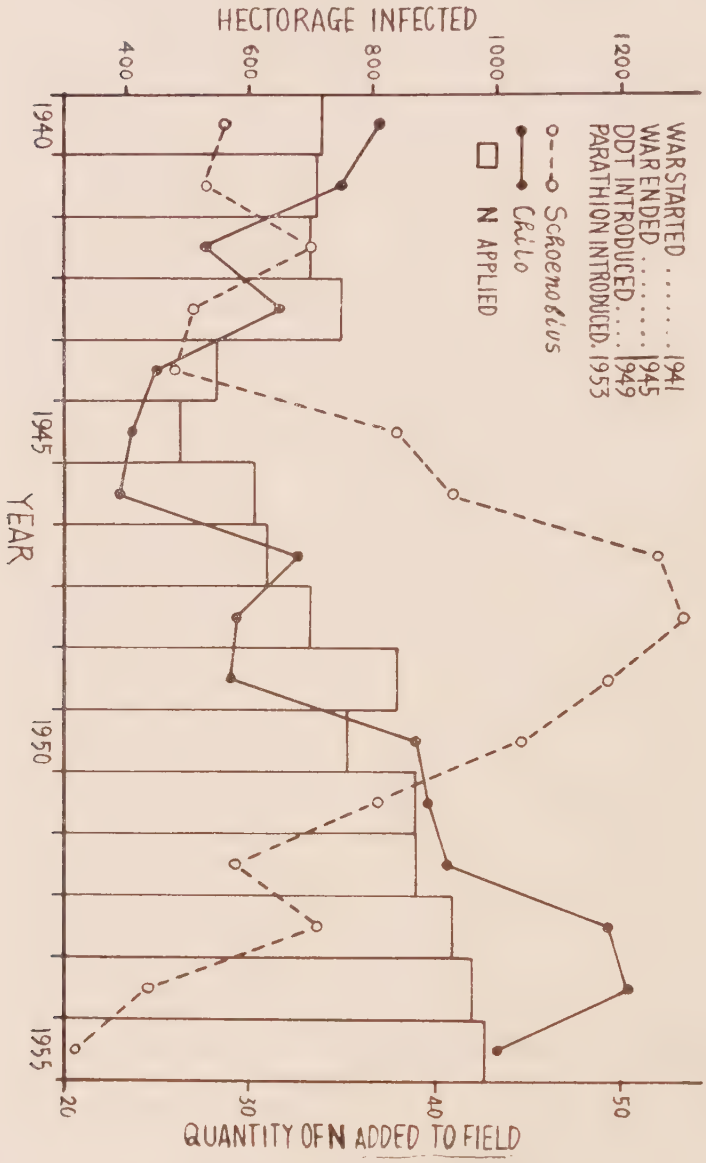

Fig. 5.—Effect of Manure on Insect Density.

The long-range statistical method of forecasting insect outbreaks proved very effective up to the time modern insecticides and early cultivation were adopted. It is quite clear that the population density, date of first emergence, number of generations and other

habits of insect pests could change from place to place, and year to year, depending chiefly on environmental fluctuation, changes in system of cultivation, and the use of insecticides. The statistical method of insect pest forecasting which is based on accumulated light trap records is bound to prove ineffective during periods of transition in cultural practices. The average readings for 2-4 years during such periods would not be consistent. However, this difficulty could be overcome if the experimental method is also conducted during the period.

The experimental method would come in handy when a pest forecasting service has to be established in places where there is an absence of any accumulated information on the population density of insects.

The two systems of forecasting indicate mainly the peak emergence of insect pests, but do not give the precise forecast on the density in the field. On the basis of the forecast, farmers apply insecticides to the rice crop, irrespective of the population density in the field. Such actions might at times prove uneconomic as there are possibilities of very intensive control measures being adopted even though the intensity of pest outbreak might be low. If methods are devised to forecast peak emergence as well as actual density in the field more precisely, control measures would not only be well timed but also prove very profitable.

In a country like Japan which is located in the temperate zone, rice cultivation is uniform and of a high standard. There is also a marked period of diapause in the development phase of insects. These two factors are conducive to the accurate forecast of insect pest outbreaks. In tropical regions where exist a wide range of rice varieties, diversity of cultural practices, continued cropping, and with no marked aestivation or diapause of insects, accurate prediction of insect pest outbreaks might prove laborious.

ACKNOWLEDGMENT

The author acknowledges with thanks the assistance rendered by the staff of the Division of Entomology and Phytopathology, National Institute of Agricultural Sciences, Nishigahara, Tokyo, in the study of the subject, and in special to Dr. H. Ishikura for the encouragement given in writing up this paper.

PROPAGATING CARISSA CARANDAS (KARAUNDA) VEGETATIVELY

By O. S. JAUHARI and R. C. MEHRA

(Government Agricultural College, Kanpur)

INTRODUCTION

Carissa carandas is one of the few fruits indigenous to India. It is popularly grown in the plains of India as an economic and protective hedge plant. It may also be cultivated as a shrub or a small tree. The plant starts bearing heavily after the age of two years. Once established, the plant is very hardy and thrives without irrigation and much care. Even as a hedge plant, it is a prolific supplier of fruits rich in vitamin 'C' and pectin. The fruit is commonly used for quality jelly, pickles and preserves. On account of its hardy nature and varied economic uses, it has immense possibilities in future commercial plantings.

This esteemed fruit plant has, so far, been propagated by seed. It is difficult to raise by cuttings. However, it may be propagated by inarching though it is not generally practised.

Jauhari and Nigam (1958) reported varying degrees of success (20, 30 and 40%) by air-layering in *Carissa* with the help of 10,000, 20,000 and 30,000 ppm. concentrations of IBA and IAA in lanolin paste. The trial was further continued to study the effect of growth regulator mixtures on rooting the air-layers of *Carissa carandas* and explore the possibilities of devising some satisfactory means of propagating this useful fruit vegetatively.

MATERIALS AND METHODS

The trial was conducted in two series, i.e., the rainy (25th August to 10th October) and Spring (2nd February to 1st April) seasons.

Growth regulators were mixed in equal proportions (2,500, 5,000 and 7,500 ppm. each), and the following combinations were prepared in lanolin paste :—

(1) Indole acetic acid mixed with Indole butyric acid ;
(2) Indole acetic acid mixed with Naphthalene acetic acid ;
(3) Indole butyric acid and Naphthalene acetic acid.

Twigs, which were one to two years old, green in colour with brown streaks and had an approximate diameter of 1.5 cms. (on 6 to 8 year old plants) were taken for the study. About 3 cms. wide bark was peeled off around the twigs with a sharp knife without injuring the underlying wood.

Different concentrations of auxin mixtures were applied evenly to the upper cut of the ring. Only lanolin paste was applied in case of control shoots. Twigs thus treated were covered with wet sphagnum moss and tied firmly with alkathene wrappers. A fortnight later, when the roots were observed piercing out of the moss, a second covering of water soaked moss was applied.

There were ten shoots for each treatment. The air-layers were detached from the parent plant after 45 days during the rainy season and after 60 days in the spring.

RESULTS

The efficacy of various concentrations of different growth regulator mixtures to root the air-layers of *Carissa* was studied during rainy and spring seasons in the year 1958-59. The data presented are the averages of 10 air-layers under each treatment.

Excellent success was achieved during the rainy season with all the auxin mixtures at different concentrations. Appreciably high root development was noted in some treatments (Table I).

(i) *Initiation of Roots.*—Twelve days after the initial treatment, the roots in greater number were seen emerging out of the moss covering in the IAA and IBA combination. A comparatively delayed root formation (18 days) was observed under 2,500 ppm. of IBA and NAA mixture.

(ii) *Rooting Percentage.*—It is well evident from Plate I that all the auxin treatments proved of considerable advantage, and outstanding success was achieved in the gootees. IAA and IBA combination induced 100% rooting at all the levels of concentrations (Fig. I, A, B and C).

IBA and NAA mixture was second in order of merit with 80%, 100% and 100% rooting under 2,500, 5,000 and 7,500 ppm. concentrations respectively (Fig. 3, A, B and C).

Though IAA and NAA combination did not prove as effective as other treatments, was far superior with 70%, 70% and 80% (Fig. 2, A, B and C) but to the control.

There was no rooting at all in the control (Fig. 4).

(iii) *Average number of Roots per rooted gootee.*—Table I reveals the average number of roots per gootee obtained under different concentrations and mixtures. An excellent number of roots (76 per gootee) was induced by 7,500 ppm. of IAA and IBA mixture. IAA and IBA mixture at 5,000 ppm. initiated 32 roots per gootee, while an average of 37 and 28 roots per gootee were found in 5,000 ppm. of IBA and NAA, and 7,500 ppm. of IAA and NAA mixtures respectively.

Meagre success was obtained in the spring season (Table 2). Rooting in air-layers required a longer duration (30 days). IAA and IBA combination at 7,500 ppm. concentration gave the best success of 30% with an average of 10 roots per air-layer and proved superior in effect over others.

TABLE I —Effect of different auxin mixtures on percentage rooting, average No. of roots, average length of the longest roots and percentage survival of Carissa carandas air-layers

S. No.	Auxin Mixtures	Concentration of each in ppm.	Percentage rooting	Av. No. of roots per rooted air-layer	Average length of the longest root in cms.	Percentage survival for 3 months in nursery
1	B–Indole acetic acid & B–Indole butyric acid ..	2,500	100	13	6·2	80
2	Do. ..	5,000	100	32	6·7	100
3	Do. ..	7,500	100	76	7·4	100
4	B–Indole acetic acid & A–Naphthalene acetic acid ..	2,500	70	8	6·4	57
5	Do. ..	5,000	70	23	6·3	71
6	Do. ..	7,500	80	28	6·0	100
7	B–Indole butyric acid & A–Naphthalene acetic acid ..	2,500	80	10	4·6	50
8	Do. ..	5,000	100	37	6·5	100
9	Do. ..	7,500	100	25	7·4	100
10	Control (Lanolin only) ..	—	—	—	—	—

TABLE II—Effect of different auxin mixtures on percentage rooting, average No. of roots, average length of the longest roots and percentage survival of Carissa carandas air-layers

S. No.	Auxin Mixtures	Concentration of each in ppm.	Percentage rooting	Av. No. of roots per rooted air-layer	Average length of the longest root in cms.	Percentage survival for 3 months in nursery
1	B–Indole acetic acid & B–Indole butyric acid ..	2,500	10	4	1·2	—
2	Do. ..	5,000	10	2	1·47	—
3	Do. ..	7,500	30	10	2·4	—
4	B–Indole acetic acid & A–Naphthalene acetic acid ..	2,500	—	—	—	—
5	Do. ..	5,000	10	4	1·5	—
6	Do. ..	7,500	—	—	—	—
7	B–Indole butyric acid & A–Naphthalene acetic acid ..	2,500	—	—	—	—
8	Do. ..	5,000	20	3	3·0	—
9	Do. ..	7,500	—	—	—	—
10	Control (Lanolin only) ..	—	—	—	—	—

SUMMARY

The results obtained are summarised below :—

(i) Cent per cent success was achieved with all the concentrations of IAA, IBA combination. But IBA and NAA combination gave cent per cent success at the levels of 5,000 and 7,500 ppm.

(ii) IAA and NAA mixture induced 70%, 70% and 80% rooting at 2,500, 5,000 and 7,500 ppm. concentrations respectively.

(iii) Rainy season was adjudged more suitable than spring for propagating *Carissa carandas* by air-layering.

(iv) No rooting was observed in controls.

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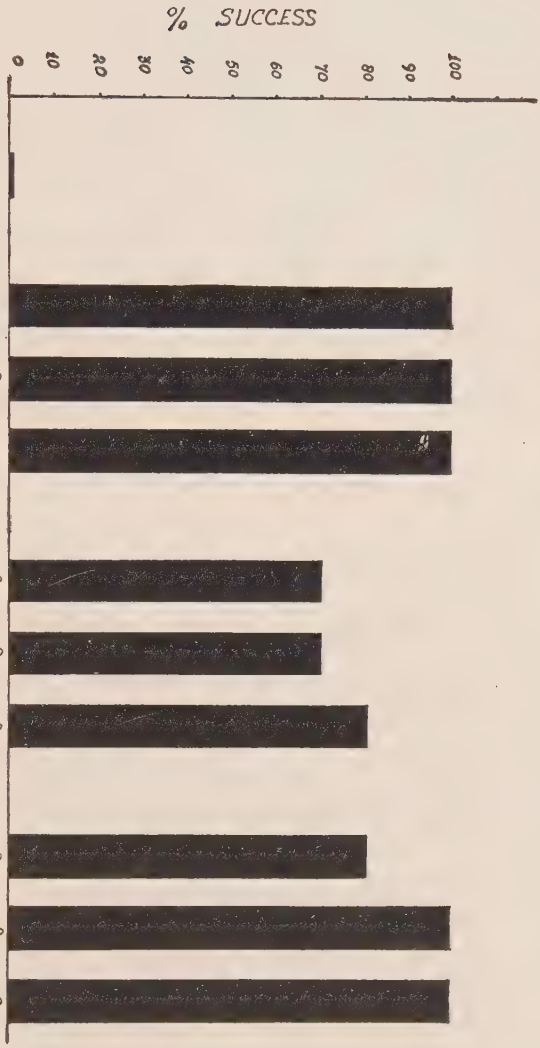
THE EFFECT OF GROWTH REGULATOR-MIXTURES ON PERCENTAGE SUCCESS IN ROOTING OF Carissa carandas AIR-LAYERS.
RAINY - SEASON
% SUCCESS
100
90
80
70
60
50
40
30
20
10
0
CONTROL
IAA + IBA
IAA + NAA
IBA + NAA
2,500
5,000
7,500
CONC. IN PPM

PLATE - 1

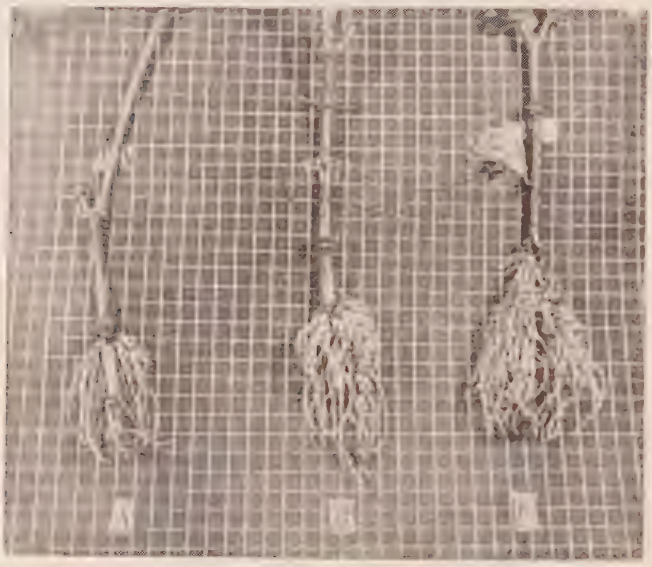

Fig. 1.—Effect of indole acetic acid and indole butyric acid combination on rooting in air-layers of *Carissa carandas* during rainy season.

A—2,500 ppm. each : B—5,000 ppm. each : and C—7,500 ppm. each.

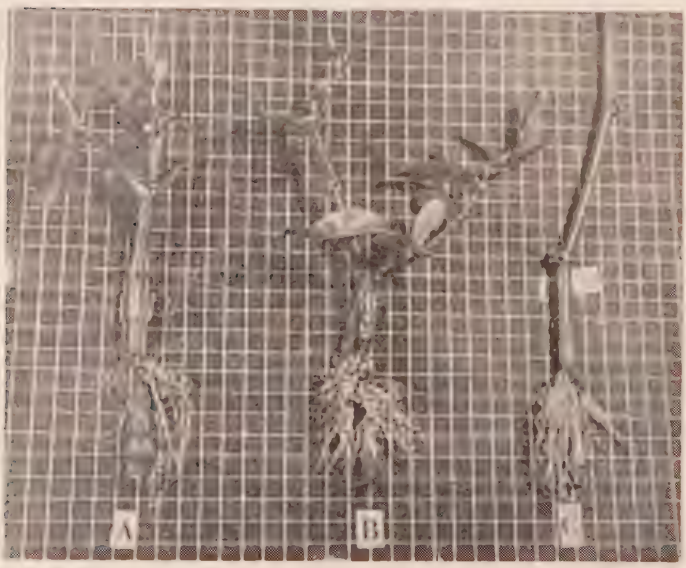

Fig. 2.—Effect of indole acetic acid and naphthalene acetic acid combination.

A—2,500 ppm. each ; B—5,000 ppm. each; and C—7,500 ppm. each.

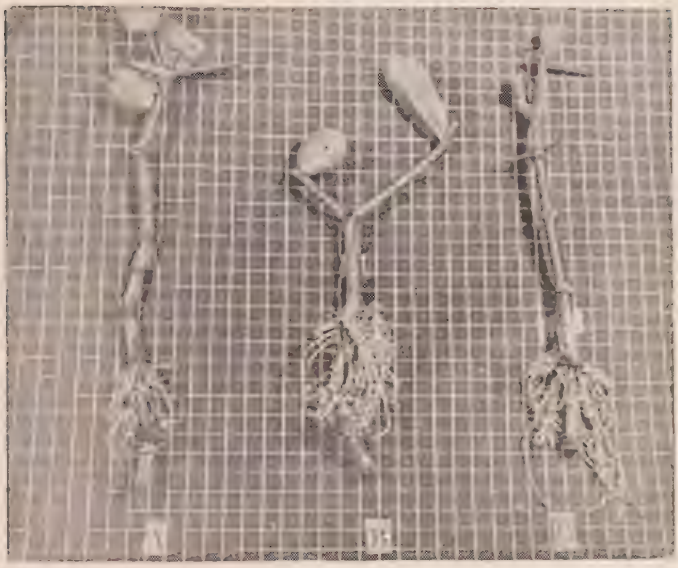

Fig. 3.— Effect of indole butyric acid and naphthalene acetic acid mixture.

A—2,500 ppm. each ; B—5,000 ppm. each ; and C—7,500 ppm. each.

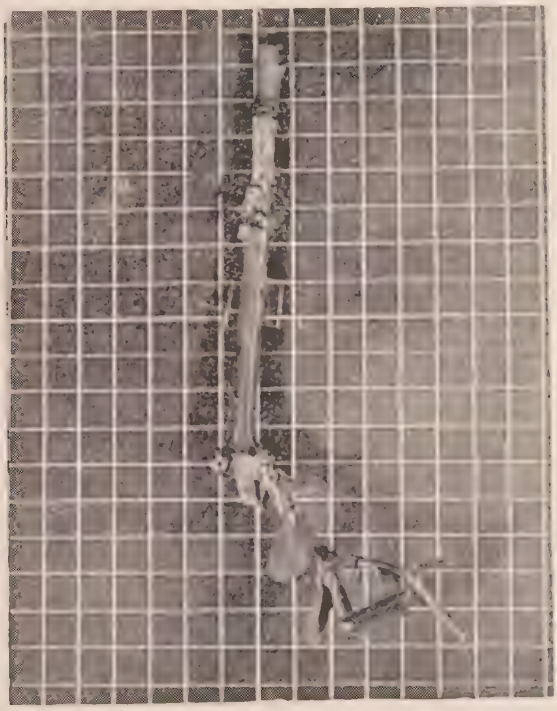

Fig 4.—Control—No rooting.

REVIEW OF EXPERIMENTS ON TESTS OF VARIETAL RESISTANCE OF CEYLON PADDY TO BLAST CAUSED BY PIRICULARIA ORYZAE (Cav.)

By G. C. MARKS and J. W. L. PEIRIS

(Division of Plant Pathology, Department of Agriculture, Ceylon)

In Ceylon, paddy varieties are screened for their resistance to Paddy Blast caused by *Piricularia oryzae* (Cav.) in the laboratory, using spore suspensions to inoculate healthy seedlings and Sakamoto's sheath inoculation method. In field tests, highland nurseries are used to determine their resistance to leaf blast and specially selected stations are used for testing resistance to Neck Rot, Node Blast, and Panicle Blast.

For purposes of assessment of varietal resistance in the field a standardised scale is used, based on the morphology of the lesions and the percentage leaf area infected by the pathogen. The observations are recorded continuously when the tests are conducted on highland nurseries so that the rate at which the disease develops in the susceptible varieties is determined in order to facilitate their subsequent classification. For this purpose only the percentage leaf area infected or destroyed is recorded as the lesion type tends to remain constant. When studying the morphology of the lesion under natural conditions the most susceptible lesion types only are observed in order to determine the resistance. When using the sheath inoculation method Dr. Y. Takahashi's method of assessment is followed.

It has been found that the best results are obtained when highland nurseries are used to test for blast resistance. All varieties can be evaluated by this method using standardised conditions for inducing the disease at any time of the year. Under these conditions, the varieties tested segregate out into two distinct groups, the highly resistant and highly susceptible ones. There are very few varieties which fall into the intermediate group of mildly susceptible and slightly resistant types. This is in contrast to the results obtained in Japan using similar techniques, where the varieties tend to fall into either mildly resistant, mildly susceptible or susceptible groups.

A survey of the resistance of the indigenous varieties showed that out of the 126 types collected from all over the island 23 proved either resistant or highly resistant to blast.

Tests for neck rot, panicle blast and node blast resistance under mudland conditions have shown that varieties graded under upland tests as mildly resistant, resistant or highly resistant have all proved extremely resistant to neck rot, &c., in inundated soils, (Table I). Field observations have borne this out, so that dual tests for leaf blast resistance and neck rot resistance as done in Japan have been, so far, found to be unnecessary. This could be explained for the following reasons :—

(i) There is a very slight annual variation in temperature in Ceylon so that there is no sharp drop in temperature during the months of September and October (i.e., during the heading and ripening period) which predisposes the plants to neck rot.

(ii) The resistance shown by the resistant *Indica* varieties is due to physiological factors, and are not markedly affected by climatic variations, and fertilizer levels. Further, this is a " true " resistance factor and is of a higher order than that shown by the *Japonicas*.

It has also been found that the resistance of the varieties graded as " highly resistant ", " resistant " and " mildly resistant " on upland nursery tests do not vary with location when grown in inundated soils. Thus we may conclude that the varieties shows resistance to the races of *Piricularia* prevalent in all areas tested, when grown under inundated conditions but we cannot as yet determine whether they will remain so in the future as these varieties have not been grown for sufficiently long periods to decide this.

Thus for present purposes, it has proved satisfactory to test the resistance of new hybrids to leaf blast in a few selected stations under upland conditions in the early generations, while the final tests for resistance to neck rot are done before release to the seed multiplication organization.

At present, work is being undertaken to determine whether races of *Piricularia oryzae* exist in the Island capable of destroying the resistance in the resistant groups of rice varieties. There is evidence that such races exist but further observations are necessary. Should virulent strains be found, the scheme of testing for blast resistance will have to be reorganised accordingly to take into consideration these biotypes of *P. oryzae*.

There is one defect in using highland nurseries for testing blast resistance. When rice is grown in dry soil for reasons still not completely elucidated, there is a very restricted silicification of the epidermal tissue in the leaf. Thus the structural resistance of the cuticle and outer walls of the epidermal cells to the disruptive physical forces exerted by the invading infection tube of *P. oryzae* is greatly reduced so that the number of lesions seen on a single leaf blade reaches astronomical proportions, especially in the case of the resistant varieties. The lower leaves in these varieties assume a rusty brown colour due to the countless pin-point lesions covering them. Thus one of the component factors for blast resistance, the mechanical resistance of the epidermis to entry of the fungus, is not tested by this method. Only the "physiological" resistance is determined. It has been postulated that physiological resistance in the *Indica* varieties is due to hypersensitivity of the cells. This is not true hypersensitivity as seen in parabiotic host pathogen associations, but due to a greatly shortened moribund stage of the infected tissue, resulting in the release of fugitoxic substances before the mycelium has time to grow out of their zone of influence. Studies by Japanese workers (Ono and Kawamura) have shown that resistance is also co-related to the collapse of cell wall, for in the resistant varieties the cells do not collapse forming large intercellular spaces, through which the fungus can migrate like in the susceptible ones where large spaces are formed. Thus the failure of the cells to shrink in the resistant varieties contributes to the resistance by confining the pathogen to foci where the fungitoxic substances are released by the moribund cells thus helping in the inactivation. This may explain why highly resistant pin-point lesions are sometimes seen in varieties where the moribund stages are protracted, for it is also noticed that the infected cells do not collapse in these tissues. It has been found that this form of resistance is evaluated on highland nurseries and is relatively stable, being influenced only slightly by cultural and environmental factors.

Corelation between Resistance to Leaf Blast in Upland Nurseries and Neck Rot

Variety	Upland Tests		Inundated Soil Tests	
	Resistance to Leaf Blast		Resistance to Neck Rot	
	Lesion Type	Grade	%Infected Pan./hill	Grade
C 12	L	SS	100	SS
C 20	L	SS	100	SS
C 104	D	RR	0	RR
Dahanala 2014	L	S	100	SS
Heenati 309	L	S	90	SS
H 4	D + S	R	0	RR
H 5	D + S	R	0	RR
H 106	L	SS	100	SS
H 501	D + S	R	0	RR
M 302	D + S	R	0	RR
M 303	S	M	0	RR
M 104	D + S	R	0	RR
M 101	D	RR	0	RR
M 304	D	RR	0	RR
Murunga 137	L	SS	100	SS
Murunga 307	L	SS	100	SS
Murunga 308	L	SS	55	S
Mas M 24	L	SS	100	SS
Sulai 301	S	MS	0	RR
Sulai 27164	L	SS	100	SS
Sinnanayan 398	L	SS	50	S
Sinnanayan 2208	L	SS	40	S
S. R. 26 B	*	RR	0	RR
Suduwi 306	L	SS	100	SS
Rathkarayal 3753	L	S	100	SS
Uvar vellai	L	SS	100	SS
Vellai Perunel 28784 ..	L	SS	100	SS
VI 28061	D + S	R	0	RR

Note :

D = Pin-point lesions
S = Small brown diamond-shaped lesions
L = Large lesions watery green, sometimes zonated, often white in colour
SS = Very susceptible
S = Fairly susceptible
MS = Moderately susceptible
MR = Moderate resistance
R = Fairly resistant
RR = Very resistant
* = Immune varieties

VETERINARY ACTIVITIES IN BETTER AND LESS DEVELOPED COUNTRIES —A COMPARISON

By Sir THOMAS DALLING

(Consultant of the Food and Agriculture Organization of the United Nations (FAO), Rome, Italy)

THE PRESENT SYSTEMS of education for veterinarians throughout the world have much in common and are designed to provide the essentials of training to enable graduates to undertake duties in different parts of the world. It has to be remembered, however, that the actual work required from veterinarians differs according to prevailing conditions in their spheres of activity. In countries in which veterinary services have been long established the work and duties of veterinarians have become, at least to some extent, regulated by public demand and by the economic and sentimental value attached to animals of all species. In such countries, which may be referred to as the better developed countries, livestock is usually more concentrated in relatively small areas and the number of veterinarians in them is relatively large. On the other hand, in countries in which the animal population is more scattered, extending over wide areas, and in which less value is attached to individual animals, there is usually a much smaller number of veterinarians and their work, in detail, often varies considerably from that carried out in the better developed countries.

One of the main differences between such areas is private veterinary practice. Although state veterinary services are essential for the control of animal diseases, especially contagious diseases, in all parts of the world and are found, in some measure, in all countries, private practice is found only to a limited extent in the less developed countries. It may be stated that, generally speaking, the work of private practitioners is concerned to a large extent with individual animals or small groups of animals, whereas a state veterinary service deals more with a country as a whole in the application of regulations and extensive schemes to control and prevent the spread of a disease and to ensure that some diseases do not enter

the country. In some countries, the state veterinary service, in addition to its veterinarians, makes use of private practitioners in a part-time capacity to assist in its activities and, especially in the less developed parts of the world, the staff may include personnel trained and experienced in some aspects of the work which is carried out under supervision of the veterinarians.

In the course of time and as conditions have changed in most countries, the work in private practices has also undergone change. With the introduction of mechanical methods in agriculture and transport work in many parts of the world, the need for horses is rapidly disappearing, with the result that the mainstay of private practice of some years ago has moved to other animals. The importance now attached to cattle, pigs, sheep, goats and poultry has meant that their owners have become more concerned with the health problems of such animals : in such work veterinarians have been much assisted by the results of research work throughout the world. Again, the interest now being taken in domestic pets, especially dogs and cats, has created a demand for veterinary services to such an extent that many veterinarians now devote their whole time to the care of such animals. Knowledge and information on the health and disease problems of these animals have increased very rapidly in the past two or three decades : the advent of women into the veterinary profession coincided to some extent with the expansion of veterinary activities on small animals. In most of the larger towns, especially in the better developed countries, clinics devoted entirely to small animal veterinary work are to be found. Rapid progress has been made in the surgery of these animals and in such clinics well equipped operating rooms are usually available, where care very similar to that given to human beings is exercised in dealing with these small animals.

Surgical work on the larger domestic animals has also advanced to a marked extent in recent years and veterinarians now undertake surgical operations which, at one time, would be considered impossible or attended with much risk. Much of the risk has been overcome by the development of more satisfactory techniques of anaesthesia.

A considerable amount of the time of a veterinarian in private practice must be spent on the farm itself. Until modern transport became available much of the veterinarian's time was occupied in travelling from farm to farm. Today, by the use of motor vehicles and even aircraft, longer distances are covered in a short space of time and, therefore, the activities of veterinarians in private practice have substantially increased in most areas.

Pakistan 1952. Animal Husbandry Laboratory, Peshawar, operated by the Central Government of Pakistan. A veterinarian of the Food and Agriculture Organisation of the United Nations advises on the use of a dry freezer for making vaccine for fighting fowl and animal diseases.

(*Through courtesy of F. A. O.*)

Whereas in former times it was uncommon to find more than one veterinarian in a practice, the tendency today is to have a number, co-operating as partners or acting as assistants, in a single practice. This system has many advantages.

Veterinarians in private practice may be appointed for part-time work for a state veterinary service. This may occupy a considerable amount of their time each day, especially in countries where extensive schemes for the eradication of a disease are in progress. On the other hand, in some parts of the world, practically every veterinarian is an employee of the state veterinary service but is permitted also to engage in private practice when it does not interfere with his state duties.

Apart from private practice, veterinarians in the more developed countries are employed on a full-time basis for other duties. Control of abattoirs falls into this category. Such appointments may be made by a Government when control of abattoirs is a function of the state. In other cases, local authorities and municipalities are responsible for abattoirs and appoint the necessary veterinary staff. In some parts of the world all livestock for slaughter and the operating of abattoirs and packing plants are carried out entirely by private enterprise. Veterinarians are employed by such companies, usually in a full-time capacity. They may be in actual charge of the different operations or may act as supervisors and advisers. In addition, veterinarians employed by the state also participate in the work.

In the more developed countries, veterinarians in private practice are assisted, especially in the diagnosis of disease, by laboratories supported by the state. This type of service has received a considerable amount of prominence within recent years and is now regarded as an essential adjunct to the control of animal health and disease. In most countries there is at least one such laboratory : in others, in addition to a central laboratory where both diagnosis and research work are carried out, there exist smaller laboratories located in different areas and equipped and staffed to ensure adequate provision for diagnosis work and for simpler types of research on the more local types of problems. Any problem which requires more facilities than those available at such local laboratories is referred to the central laboratory where extensive research work can be carried out. This system of local investigation of disease problems is proving to be of high value : co-operation between the veterinarians in private practice and the local veterinary investigators is revealing problems of animal health and disease, the solution of which is of considerable economic importance to a country. These local veterinary investigators acquire a large amount of information on animal health problems

and often, from their work, the solution of a problem affecting a whole country or area is solved.

An anxious mother watches as her baby is given an anti-rabies shot in the inoculation room at the anti-rabies centre in Mexico City.

(*Through courtesy of F. A. O.*)

More interest is being taken in the health of wild animals in captivity and it is now a normal procedure to appoint veterinarians to zoological gardens to advise on feeding problems, control of disease and the general conditions under which such animals are maintained.

Mention must also be made of the excellent work carried out in a number of countries by veterinarians employed by private or commercial companies for the production of biological and chemical and other products which are now in everyday use in the prevention and control of animal diseases. At such establishments extensive research work is also carried out and the world, in general, owes much of its knowledge concerning the maintenance of health and disease control to the activities of the veterinary staff there.

In some parts of the world where animals are kept under ranch conditions, veterinarians in private practice give veterinary attention on an extensive scale. Such work embraces the adoption of measures to prevent diseases which are prevalent in the district : vaccines and other biological products are used at the appropriate times and the veterinarians often have to spend quite long periods on the ranches at a given time to carry out the various operations.

In the less developed countries, animal health problems are largely the concern of the state veterinary services which are developed and enlarged as the work develops. The essential need for veterinary services is recognized in all these countries and their extension is often limited only by the number of veterinarians available. It can be appreciated that there is an ambition to employ veterinarians trained in the country itself or in the area. This has not always been possible and it has been necessary to appoint veterinarians trained in the better developed countries as personnel of the state veterinary services. This has had its advantages, for it has meant that solid foundations have been laid by well-trained veterinarians and on such foundations it has been possible to build up services which, following expansion, are proving their worth in world economy. As times goes on more facilities are being provided for the local education and training of veterinarians in parts of the world in which less developed countries exist. This, together with the hoped-for improvement in conditions for locally-trained veterinarians, will encourage more young people to graduate as veterinarians and will obviate the need to send students from such countries to veterinary schools in the better developed parts of the world for training.

It can be well appreciated that, in these areas, because of the large numbers of livestock scattered over wide areas and the conditions

Rabies, usually transmitted to humans through bites inflicted by rabid dogs, can also become a scourge to livestock. Mexico is waging an intensive campaign to enlist the aid of the people in the eradication of the disease in both humans and cattle.

At the Palo Alto research centre where anti-rabies vaccine is prepared for use in campaign against rabies in cattle, laboratory workers inject the vaccine into specially incubated eggs. (*Through courtesy of F. A. O.*)

under which they are maintained, all the work on animal health and disease control cannot be carried out by veterinarians. This has resulted in the employment of lay staff who have undergone some training along special lines, working under the supervision of veterinarians. These men are indispensable today and the result of the duties they carry out is reflected in the progress now being made in the improvement of animal health in many parts of the world.

The work of a state veterinary service in the less developed countries must be essentially concerned, in the first place, with the control and prevention of contagious and infectious diseases. Generally speaking, the individual animal is of little consequence : the object of the veterinary activities is to free groups of animals from disease, and to prevent the occurrence of disease in a locality. Thus, large numbers of animals are treated at one time and at appropriate periods and places. Team work is the keynote in such areas. Naturally, the recognized and prevalent diseases are now and will continue to be given priority in the work of such veterinary services. It is highly encouraging to note the progress, sometimes rapid, that is being made in the control and eradication of some of the diseases which, at one time, were prevalent in such areas. Attention is always being given to diseases which may have been recently introduced or which may have been unnoticed in the past. In this work, veterinarians are greatly assisted by the observations carried out in other parts of the world and by the results of work from diagnosis and research laboratories in the area and elsewhere. Despite the precautions taken to prevent the introduction of new diseases into an area, spread from outside the area sometimes occurs : the early recognition of the infectious agent is essential so that recognized control measures may be brought into force.

There has always been much discussion on the part which veterinarians should play in animal husbandry and nutrition of livestock and, although it may be claimed that animal disease control is a subject apart, there is undoubtedly a close link between them. This is marked in the maintenance and improvement of animal health, especially in the less developed areas of the world, and necessitates a good knowledge of animal husbandry by veterinarians in such localities. This knowledge has to be acquired during the training period as well as by experience. Animal husbandry in all its aspects must be one of the important subjects dealt with at veterinary schools in these parts of the world, where livestock owners depend to a remarkable extent on the discussions with, and the advice received from, veterinarians. It often happens that veterinarians, in the course

of their travels in these areas, are consulted on many problems pertaining not only to animals but also to human beings and it is of interest to record that in at least one veterinary school a short course in human medicine is included in the veterinary course.

As animal production is being improved in the less developed countries, the importation of valuable breeding animals is taking place. While these animals have undergone examination before export and have been found free from infectious diseases, their further examination on arrival is necessary, in order to minimise any risk of the introduction of any specific infectious condition. Such valuable animals must also receive careful veterinary attention to prevent their acquiring any local disease to which they may be susceptible and immediate treatment, should any such infectious condition be diagnosed in them. Thus, although in general individual animals in the less developed countries do not normally receive much attention, exceptions are made with imported stock.

While the bulk of the veterinary work in these areas is carried out by state veterinary services, veterinarians in private practice are also found, especially in the larger towns. As a country becomes developed and herds and flocks of good quality animals are established, the demands for the services of veterinarians in private practice increase. There is also considerable scope for such veterinarians in race-horse work and in attending to the health and diseases of domestic pets, e.g., dogs and cats.

Diseases, probably less spectacular than those normally found in these less developed areas, are gradually receiving attention and their control will be increased as more veterinarians become available.

One of the objectives in improving animal production in the less developed areas of the world is to set up export trade in livestock and animal products. In some countries a beginning has already been made in this work and abattoirs under the control of veterinarians are available for dealing with a considerable number of animals. Economically, the health of livestock will play a considerable part in the success of such operations. Control and eradication of the already recognized diseases, research work carried out by governments or by private enterprise on the causes and control of hitherto unrecognized diseases and the provision of the necessary biological products and medicaments, are all essential parts of such schemes. It is encouraging to note that these subjects are recognized and that action is now being taken in some areas to develop all this work to as great an extent as circumstances will allow.

CONTROL OF INFECTIOUS DISEASES OF ANIMALS

By Sir THOMAS DALLING

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ALTHOUGH THE WORDS "infectious" and "contagious" when applied to disease are often thought to have the same meaning, there is a distinct difference. An infectious disease is actually caused by some specific agent and the condition set up by that agent is termed an "infection". If, now, that agent can be transmitted from the infected animal to other susceptible animals which, in their turn, develop the same condition, the disease produced is termed a "contagious" disease. In other words, all contagious diseases are infectious but all diseases are not necessarily contagious. The diseases with which we shall deal in this and the next two articles are, in fact, both infectious and contagious, caused by what are popularly called "germs".

In the present article we shall discuss some of the diseases which are highly contagious, spreading rapidly and causing death of infected animals or lowered production or both.

We cannot do better than begin with *foot-and-mouth disease,* a disease whose name is familiar all over the world. The cause is a small particle of living matter called a virus which, in susceptible animals, is responsible for, among other things, the obvious changes in the mouth and feet from which the disease is recognized. Other results of the infection, which are not so obvious, are found in the stomach (rumen) and the heart, those in the heart being sometimes responsible for the sudden death of the infected animal, may be some considerable time after apparent recovery has taken place. All cloven-footed animals are susceptible to the infection. In some parts of the world foot-and-mouth disease is considered as probably the most important disease of livestock ; in other countries, its occurrence is not generally regarded as a serious problem. There are reasons for these different views. In countries in which there is a relatively high concentration of livestock and where intensive production is the objective, the chances of spread of the infection are very great and there may be a heavy loss in production reflected not only in the finances of

4 ——J. N. R 5926 (11/59).

the individual farmer but in the economy of the country. It is estimated, for example, that the losses which arose from the 1951-52 epizootic in Europe amounted to at least $400,000,000. This loss represented mainly reduction in production during or subsequent to individual outbreaks or groups of outbreaks and the disruption of national and international trade in livestock and livestock products. In the less developed countries, very often the disease is milder in character and the results are not so disastrous : in many of these countries the disease is always present and is generally looked upon more as a nuisance, causing only some temporary inconveniences. This outlook, however, is not to be encouraged for, periodically, the mild disease gives place to an acute phase with heavier losses, especially from deaths of infected young stock ; the development of an export trade in livestock and livestock products in such infected regions will continue to be much handicapped so long as foot-and-mouth disease is present.

Much progress is being made in controlling foot-and-mouth disease in some individual countries and the measures adopted by veterinary authorities, often as a result of assistance given by international organizations, is preventing the entrance of the infection into countries or groups of countries. While it is possible to apply a total out-and-out slaughter policy in some countries whereby any introduced infection is usually eradicated and the country is again free from the disease until a further introduction takes place, it is necessary in some countries, especially where the disease is endemic or where there is considerable exposure to the introduction of the infection, to carry out a vaccination campaign. The extent to which this is practised depends largely on circumstances and varies from annual vaccination of all or practically all the cattle population to vaccination of cattle in frontier areas and in prescribed districts following an outbreak. Vaccination is certainly playing an important part in controlling the disease in many countries. It is realised, however, that the objective behind vaccination is to reduce the incidence of the disease to such a low figure that a slaughter policy becomes economically possible. That stage is in sight in some countries and slaughter is being coupled with vaccination in others. Foot-and-mouth disease control by vaccination is made somewhat difficult because of the existence of different types of the causal virus, against each of which it is necessary to give protection by vaccination. For a long time three distinctly different types of the virus were recognized in most infected countries throughout the world : four further types have now been shown to exist, three of which are at present confined to Africa and one to Asia. Again, some variations have been shown to exist in each of the originally known three types, necessitating the development of vaccines for use against

them. Many of the difficulties in the preparation and production of foot-and-mouth disease vaccines are being overcome. New techniques are being used and it is probably only a matter of time until the old

Mouth lesions due to Foot-and-Mouth Disease.

(Photograph through courtesy of the F. A. O.)

methods of preparation are replaced. Vaccines, as presently used, give good results and the disease can be rapidly controlled and spread prevented by vaccination. In countries in which regular vaccination is carried out suitable vaccines for protection against the types of the virus most likely to be present in or to be introduced into the country are used. It is always necessary to ascertain the type of the virus in any new outbreak whether or not a vaccination policy is being practised : this is done in laboratories which are equipped for this work. Such laboratories exist in several countries in different parts of the world : for special work on typing of the virus and for assisting countries, especially in Africa and Asia, in determining the types causing outbreaks, the Research Institute (Animal Viruses), Pirbright, England, is now recognized as the World Foot-and-Mouth Disease Reference Laboratory. Vaccination is carried out almost entirely in cattle : there has still to be elaborated a more efficient product for the protection of pigs, in which foot-and-mouth disease may cause much damage and from which the disease often spreads to cattle. In addition to a slaughter policy or vaccination, it is highly important in preventing the spread of the infection that early reporting of outbreaks takes place, that severe restrictions on the movements of animals in an infected area are imposed and that careful and thorough disinfection of infected premises is carried out before susceptible animals are again introduced.

While the distribution of the seven different types of the virus is fairly well known today, their appearance in new areas is being carefully watched so that measures for the prevention of their spread can receive attention. It is generally agreed that the eradication of foot-and-mouth disease demands both national and international action. A beginning has been made to eradicate the disease from the whole of Europe through the establishment of the European Commission for the Control of Foot-and-Mouth Disease. The intention is, eventually, to extend international control and eradication plans to other regions and, finally, at some stage to link up their activities and so cover as much of the world as possible.

At one time it was considered that *rinderpest* (cattle plague) was probably the most important contagious disease of livestock, mainly because of the high mortality among infected animals. Although the disease has been widespread in different parts of the world, it is now confined to certain regions of Africa and Asia and, even there, it is gradually being brought under control although severe outbreaks

The Food and Agriculture Organisation of the United Nations (F. A. O.) has sent a mission to Ethiopia to help modernize the country's agriculture and forestry. Working there are experts in crop production, animal production animal diseases' control, rural welfare, forest development and nutrition. The mission includes a team of F. A. O. veterinarians.

This photograph shows Dr. Razmilic, F. A. O. Veterinarian, watching an Ethiopian vaccinator administering anti-rinderpest vaccine.

(*Through courtesy of the FAO*)

periodically occur. The high mortality makes rinderpest a more spectacular disease than some others in which the losses, apart from actual deaths, may be very high. Strict measures against its introduction are taken by the veterinary authorities in countries which have always been free or from which the disease has been eradicated.

Immunising of susceptible animals against the infection is now practised on an extensive scale in infected countries by the use of suitable vaccines. Fortunately, as opposed to foot-and-mouth disease, there is no evidence that more than one type of the causal virus exists : this means that the production of satisfactory vaccines is simpler. The actual vaccines now in use differ markedly from those available in the earlier days of rinderpest control. The introduction of new methods of virus-vaccine preparation has resulted in the production of products which can be stored under suitable conditions for long periods, ready to be used when required. This stage has not yet been reached in foot-and-mouth disease vaccine production. Vaccines now in use in the control of rinderpest consist mostly of the living virus in an attenuated or feebly virulent form, attained by passing the virulent virus through a species of animal of low susceptibility, e.g., goats or rabbits or through the developing chick in fertile eggs. Susceptible animals, e.g., cattle and buffaloes, receiving a single dose of such a vaccine are rendered immune to natural infection for long periods, probably for several years or even for life. This finding simplifies the work in operating vaccination campaigns for the control of the disease. At the beginning of a campaign all adult susceptible cattle and buffaloes, in a satisfactory state of health, receive a dose of vaccine : these animals should not require any further vaccination. Periodically, vaccination is again carried out in the area when any animal not already vaccinated is dealt with. This includes animals which were considered too young to be treated on a former occasion or have been born since the others were vaccinated.

Compaigns for the control of rinderpest differ from those against foot-and-mouth disease, for a serviceable immunity induced by the vaccines at present in use for the latter disease is of relatively short duration and injections have to be repeated at intervals of a few months and certainly once a year. In India, today, a carefully planned vaccination campaign for the control of rinderpest is being successfully operated throughout the whole of the sub-continent. A few years ago a concentrated effort by the veterinary authorities in Thailand eradicated rinderpest from the whole of the country. Except for some occasional introductions, which have been dealt with successfully, the country has remained free from the disease. These examples illustrate the adoption of measures by individual countries : while they prove

successful in controlling and even eradicating the disease in a specified area there is need for international collaborative effort finally to clear rinderpest from all parts of the world.

It has been found that the degree of attenuation, i.e., reduced virulence of the virus in a vaccine, must vary according to the susceptibility of the animals to be treated. This has been provided for and vaccines are now available for use in countries and regions where even the most highly susceptible cattle and buffaloes are present.

The occurrence of rinderpest in wild ruminants will probably remain as a source of infection in some parts of the world so that vaccination campaigns will still be needed.

The presence of rinderpest is preventing, to a considerable extent, the development of an export trade in livestock and products of animal origin in some parts of the world. It must be expected that countries free from the disease will continue to refuse such imports so long as rinderpest is present in the exporting country or until scientific evidence shows the conditions under which there would be no risk of introducing the causal virus from such infected countries.

Another example of a contagious disease, at one time prevalent in many parts of the world and now confined to some specified areas, is *contagious bovine pleuro-pneumonia.* Even before modern methods of control became available, the disease was eradicated from several regions by veterinary activities, and precautions taken to prevent its re-introduction have proved entirely successful. Today, contagious bovine pleuro-pneumonia occurs in some of the northern, eastern, western and central parts of Africa, in Australia where it is endemic in the northern area with sporadic outbreaks in southern districts associated with the movement of infected cattle, in Assam (India) and in a few European countries in which it is being satisfactorily controlled and eradication is in sight.

While the presence of the infection in an acute form in a group of cattle may cause a high mortality, the most dangerous animals causing spread are those which have recovered and become " carriers " of the disease. In such animals, the affected portions of the lungs become sealed off and may remain in this condition for long periods : these lung areas, however, still contain the virulent causal micro-organism and, following a lowering of the vitality of the animal due to any form of stress such as long journeys and periods of drought, a " break-down " occurs and the infection spreads to susceptible animals.

Clinical examination of acutely infected animals usually detects the disease ; the post-mortem appearance of affected lungs is very typical of the infection. In examining a group of animals among which the

infection is present, all of which may not show the typical clinical picture, it is necessary to make use of laboratory tests in which the serum of the blood is used.

Contagious bovine pleuro-pneumonia can be prevented to a great extent in infected areas by vaccination of susceptible animals. A considerable amount of research work on the production of vaccines has been carried out and is still in progress in the different infected countries. For many years, a living culture of the causal organism inoculated into the tail has been used in Australia, with good results : many vaccinated animals are capable of resisting infection within a few days and remain in a protected state for at least three years. A very small number of excessive tail reactions are reported and their occurrence in vaccinated calves may be followed by heart and joint complications. Other types of vaccine being studied in different countries include those containing the causal agent in different stages of attenuation, cultivated in the developing chick embryo and the causal agent treated by chemical agents to which an adjuvant is added. In controlling the disease, it must be recognised that spread takes place from already infected animals and that their movement into non-infected areas is the important source of new infections.

Pleuro-pneumonia in goats and sometimes in sheep causes much loss in some parts of the world : the cause, however, is probably quite different from that of the disease in cattle.

Members of the pasteurella group of micro-organisms are the causal agents of, or are associated with, some diseases of animals and birds. The group contains several types of pasteurellae and some may cause specific diseases. Such a disease is *haemorrhagic septicaemia* (barbone) of bovines which occurs especially during and after the rainy season in some tropical and semi-tropical parts of Asia and Africa. The name " haemorrhagic septicaemia " is sometimes loosely used with reference to other diseases, the causal agents of which may yet have to be defined : with some of them, pasteurellae may be associated, probably in the role of secondary infectors. It has now been shown that the " haemorrhagic septicaemia " or " barbone " is, almost certainly, caused by one type, and one type only, of a pasteurella (*Pasteurella multecida*—Roberts type I).

Unless immunisation of susceptible cattle and buffaloes is carried out in infected areas, there may be a high mortality from the disease : the occurrence of the disease often coincides with the time when the animals are much required for land cultivation purposes. The type of vaccine mostly used has been a chemically-treated liquid culture of pasteurellae isolated from infected animals. While such vaccine

The Honduras Cattle farmers run almost 1,150,000 head of cattle, but poor range conditions and generations of poor husbandry have made them low producers of milk and meat. To help the Government revitalise the cattle industry, the Food and Agriculture Organisation of the United Nations (FAO) sent in 1954 three veterinarians to advise on disease control, on the improvement of the field service to farmers in the remote areas, and to help operate and train personnel in a central veterinary laboratory. FAO also provided a large amount of laboratory equipment, and vaccine production has made considerable progress. In 1955, FAO added to its team an expert in artificial insemination, who will help develop an artificial insemination centre at San Pedro Sula, the most important livestock district. The Government will also establish a modern breeding station and provide AI from selected indigenous and imported bulls. The station will also serve as a training ground for inseminators.

This photograph shows a laboratory assistant vaccinating cattle against blackleg disease.

(*Through courtesy of FAO*)

gives some beneficial results, the degree of immunity induced is relatively low and of such short duration that, in some districts, it has been necessary to repeat vaccination during the season of the infection. Recent research work has resulted in the production of vaccines which give better immunity for a longer period. It has been shown that the immunising substance is contained in the capsule which surrounds the causal pasteurella. This capsule is largely destroyed during artificial cultivation of the micro-organism : it is necessary, therefore, that very young cultures are used for the production of vaccine. Again, the pasteurella loses its immunising value if it is subjected to a series of sub-cultivations ; hence, strains of the micro-organisms very recently isolated from infected animals are necessary. The mixture of these cultures with an adjuvant has been shown to be of much importance in the preparation of an efficient vaccine and good results are reported following the injection of vaccines prepared by methods which make use of such discoveries. Modern vaccines for use in the control of haemorrhagic septicaemia meet the necessary requirements, viz., they can be produced in bulk ; they are easy to administer ; they do not produce undesirable reactions ; they produce immunity of sufficiently high order and duration to protect susceptible animals for the required period. Vaccination campaigns should not be difficult to arrange because the time of the annual occurrence of the disease is usually known within limits.

While there are many diseases of poultry of considerable economic importance in most countries, that which has caused greatest loss to the industry is probably *Newcastle disease* (Ranikhet disease). There are few parts of the world, where poultry are kept on an extensive scale, free from this virus infection. At one time it was thought that the disease existed only in an acute form from which practically all infected birds died. We know now that there is a much milder type in some areas, causing losses through lowered egg production and interference with the general health of poultry. Although this latter type of the disease may not be accompanied by many deaths in a flock, periodically the acute form appears in infected flocks with disastrous results. The modern methods of intensive poultry husbandry favour rapid spread of the infection. Reliable laboratory tests for which samples of blood are used are now available for the detection of the disease, including the milder forms.

Much study has been made of the control of Newcastle disease. In some countries a slaughter policy is practised : all the fowls in an infected flock are destroyed and burned or buried and the premises are thoroughly disinfected before re-stocking is permitted. For economic reasons this method cannot be carried out today in many parts

Burma—Dr. Paul Schyna, Poultry Specialist of the Food and Agriculture Organisation (FAO), demonstrates the technique of inoculating a bird, against Newcastle Disease, to Burmese technicians at the Insein Veterinary College.

(Through courtesy of FAO).

of the world. There are, however, vaccines which give satisfactory immunity against the infection. Although different vaccines are in use in different countries and the methods of their application vary, the best results appear to be obtained from vaccines composed of the living causal virus, the virulence of which is such that it does not cause infection in susceptible fowls. The causal virus used as a vaccine is now usually cultivated in developing chick embryos. Very young chicks may become infected and high mortality among them may occur. They may be protected to a considerable extent by the satisfactory immunisation of the breeding fowls, the fertile eggs from which contain protective antibodies which are passed on to the chick in the egg. Such immunity, however, is of comparatively short duration, continuing at an adequate level for only a relatively short time ; further immunisation of such chicks at a few weeks of age becomes necessary. Some recent work has shown that very young susceptible chicks may also be protected by the use of a vaccine prepared from a strain of the virus found in England in a naturally-attenuated condition. Here again, the immunity is of short duration and further immunisation is required at a later date. The virus-vaccine may be applied, especially in young chicks, by inhalation, through depositing it on nasal openings ; it may also be dropped into the conjunctival sac of the eye. In older fowls, a more potent type of vaccine is often given into the wing web. Experience has shown that, using vaccine prepared from the above-mentioned naturally-attenuated strain of virus simultaneously with a vaccine prepared from a mild strain of the virus which causes fowl pox, young chicks may be protected at the same time temporarily against both Newcastle disease and fowl pox.

METEOROLOGICAL REPORT

Summary for January-March, 1959

ORDINARY NORTH-EAST MONSOON weather prevailed over the Island during January. During mid-January the monsoon was active and resulted in rain in the north and east with fairly widespread afternoon and evening thundershowers in other parts of the country. The greater monthly totals (of the order of 20 inches) were recorded in the north-eastern hill-country. Least rainfall, totals below 2 inches, was experienced in the west-central areas. Rainfall was below normal over most parts of the Island, the larger deficits being recorded along the northern and eastern slopes of the central hills.

Afternoon and evening thundershowers continued in the south-west quarter during the first five days of February. Between the 18th and 23rd of the month north-east monsoon rain was again in evidence in the north and east while scattered thundery showers were experienced in the south-west. Dry weather prevailed during the rest of the month. The greater monthly totals (10 to 15 inches) were recorded in isolated places in the east and south-west while least rainfall (totals below 2 inches) was experienced in the northern half of the Island. About 30 stations received no rain at all. Rainfall was below normal over most parts of the Island, particularly in the north-east. Excesses were experienced in places in the southern half of the Island.

Typical inter-monsoon weather prevailed during March. Afternoon and evening thundershowers were experienced in places in the south-west quarter from the 11th to the 25th with a few scattered thundery showers in the north and east between the 19th and 23rd. Fairly widespread thunderstorms were in evidence again from the 29th. The rest of the month was practically dry. The greater monthly totals (10 to 15 inches) were recorded along the southern and western slopes of the hills. Least rainfall (totals below 2 inches) was experienced in the north and east. As many as 65 stations received no rain at all. Rainfall was below normal practically throughout the Island, the

bigger deficits (of the order of 10 inches) being recorded in the south-west. Only a few slight excesses were experienced during the month.

A. P. KANDASAMY,
Director.

Department of Meteorology,
Bullers Road,
Colombo 7, June 19, 1959.

Meteorological Report for the Quarter January to March, 1959

	JANUARY								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	No. of Days	Offset
Anuradhapura	84·9	+1·5	69·7	+0·5	77	95	5·06	6	—0·73
Badulla	77·8	+1·6	65·0	+1·2	77	92	5·62	11	—4·70
Batticaloa	83·0	+1·5	75·4	1·8	78	88	4·35	11	—8·53
Colombo	87·5	+1·1	73·0	+1·2	68	84	1·75	6	—2·21
Diyatalawa	73·8	+2·0	58·44	+0·7	80	97	4·26	10	—2·38
Galle	85·4	+1·6	74·1	+1·1	72	81	2·611	9	—1·27
M'Illuppallama	85·2	+1·7	71·7	+2·6	74	78	2·77	6	—2·77
Hambantota	85·8	+0·9	73·9	+1·3	73	88	4·57	7	+0·57
Jaffna	84·3	+1·3	72·7	+0·8	70	90	2·377	8	—2·04
Kandy	84·9	+2·7	66·4	+1·5	68	92	0·888	9	—5·86
Kankesanturai	84·3	+1·3	75·1	+0·2	71	82	3·488	6	+0·06
Kurunegala	88·8	+2·4	69·4	—0·4	95	95	0·51	8	—4·60
Mannar	84·8	+1·5	75·0	+0·8	86	87	1·64	5	—2·20
Nuwara Eliya	70·5	+2·7	46·6	—·05	74	82	3·711	9	—3·25
Puttalam	88·0	+2·5	71·0	+1·0	66	90	0·88	5	—2·55
Ratmalana	87·9	+0·9	72·5	+1·1	71	93	0·57	6	—3·58
Ratnapura	91·5	+2·2	72·0	+0·9	70	95	4·49	12	—1·77
Talawakele	74·5	-0·3	52·22	—3·2	65	87	2·54	8	—1·32
Trincomalee	83·1	+2·6	77·1	+1·8	78	76	5·91	6	—2·60

	FEBRUARY								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	No. of Days	Offset
Anuradhapura ..	89·9	+2·7	69·7	0·044	67	95	0·66	3	—1·06
Badulla ..	80·7	+1·8	62·7	—0·4	70	89	3·91	7	—0·74
Batticaloa ..	84·4	+1·5	74·5	+0·8	77	90	1·34	4	—2·87
Colombo ..	87·4	+1·5	74·5	+0·8	72	93	2·68	6	0·088
Diyatalawa ..	87·4	+0·3	72·8	+0·6	65	85	3·14		+0·7
Diyatalawa ..	77·9	+3·0	56·2	—0·7	65	85	3·14		+0·77
Galle ..	86·0	+0·9	74·1	+0·5	68	84	4·97	9	+1·88
M'Illuppallama ..	86·7	+0·8	73·5	+0·5	71	88	2·68	2	+1·20
Hambantota ..	87·0	+1·4	73·4	+1·2	66	90	0·73	2	—0·73
Jaffna ..	87·4	+2·0	65·2	+0·9	61	92	0·98	5	—1·41
Kandy ..	86·7	+2·0	73·3	—0·7	68	88	—0·02	1	—1·61
Kankesantura ..	92·0	+2·1	69·5	0	60	97	2·79	6	+0·80
Mannar ..	86·4	+2·5	74·7	+0·9	68	90	—1·33	2	—1·33
Nuwara Eliya ..	72·2	+2·6	44·0	—1·3	62	78	3·38	6	+1·39
Puttalam ..	90·8	+2·5	71·4	+1·2	64	88	0·11	1	—1·26
Ratmalana ..	87·9	+0·5	72·4	+1·1	72	93	4·56	6	+1·20
Ratnapura ..	92·1	+0·5	71·5	0	68	95	9·29	1	+3·99
Talawakelle ..	76·0	—0·5	52·4	—2·0	87	78	2·68	5	+0·71
Trincomalee ..	85·9	+3·4	77·0	+1·2	67	78	0·18	1	—2·49

	MARCH								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	No. of Days	Offset
Anuradhapura ..	98·6	+7·1	69·6	—2·0	54	95	1·26	4	—1·26
Badulla ..	84·1	+1·7	62·4	—1·9	64	91	0·40	5	—4·65
Batticaloa ..	86·7	+1·3	74·3	—0·8	71	90	0·36	4	—3·11
Colombo ..	89·5	+1·7	74·0	0	65	93	0·51	3	—4·15
Diyatalawa ..	80·8	+3·2	55·3	—2·7	88	0·36	88	5	—4·53
Galle ..	86·9	+0·6	75·2	+0·2	67	82	1·89	6	—3·42
M'Illuppallama ..	95·4	+3·4	68·2	—3·3	51	90	1·50	3	—3·14
Hambantota ..	87·8	+0·8	74·5	+0·2	68	86	0·0	3	—3·32
Jaffna ..	89·7	+1·0	75·0	—0·9	63	86	0	—	—1·38
Kandy ..	91·4	+3·5	65·1	—2·0	53	92	0·83	6	—4·59
Kankesantura ..	89·6	+0·9	73·2	—2·1	62	86	0	—	—1·47
Kurunegala ..	96·6	+3·9	70·9	—1·1	52	93	3·56	5	—2·72
Mannar ..	90·4	+1·1	74·6	—0·9	67	90	0	—	—1·84
Nuwara Eliya ..	73·6	+2·7	42·4	—4·2	66	81	——	2	—3.61
Puttalam ..	92.2	+2·3	72·7	—0·2	58	83	0·38	2	—2·70
Ratmalana ..	89·5	+1·3	73·9	0	68	95	1·38	4	—5·10
Ratnapura ..	94·0	+1·9	72·2	—0·3	63	93	8·22	12	—2·16
Talawakele ..	77·5	—0·3	51·8	—3·6	56	67	1·04	4	—3·58
Trincomalee ..	88·6	+3·0	76·6	0	64	79	0·06	1	—2·24

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